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MATERIALS BUREAU

TECHNICAL REPORT 87-1

# ASPHALT CEMENT MONITOR PROGRAM

# FALL 1986

MARCH 1987

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NEW YORK STATE DEPARTMENT OF TRANSPORTATION
MARIO M. CUOMO, Governor
FRANKLIN E. WHITE, Commissioner

TECHNICAL REPORT 87-1

# ASPHALT CEMENT MONITOR PROGRAM
# FALL 1986

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March 1987

MATERIALS BUREAU
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## Preface

Each year the Materials Bureau conducts a monitor testing program in cooperation with various suppliers of asphalt cement. Samples are obtained by Bureau personnel and split for testing by both the supplier and the Bureau in accordance with standard AASHTO test procedures. This report summarizes the results of the 1986 program.

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## I. Introduction

During July and August 1986, personnel from the Materials Bureau Chemistry Laboratory Section obtained twenty-eight samples from eighteen suppliers of asphalt cement. These samples represented many of the sources which had supplied material to the Department during the 1986 construction season including Boscan, Maya, Mid-Continent, Canadian, Arab, Venezuelan and other various crude sources.

At the time of sampling, the twenty-eight samples were split into two parts. One part was given to the asphalt supplier while the other was returned to the Bureau's Laboratory. All tests were conducted in accordance with the applicable AASHTO test procedures.

Two standard test report forms and one sample identification form were provided by the Bureau for recording sample information and all test results. Each supplier submitted the test results to the Bureau for review and incorporation into this report.

## II. Sample Information

A. The distribution of the samples by grade was as follows:

| Grade | Number of Samples |
|---|---|
| Flux | 3 |
| AC-5 | 2 |
| AC-10 | 2 |
| AC-15 | 6 |
| AC-20 | 11 |
| 85/100 | 4 |

B. The supplier, location, crude source and lot numbers are tabulated below.

Flux

| Supplier | Location | Lot | Crude Source |
|---|---|---|---|
| Chevron | Perth Amboy, NJ | 18 | Mexico Mayan |
| Cibro | Albany, NY | 35 | Boscan |
| Marathon | Tonawanda, NY | 16 | Mid-Continent and Canadian |

AC-5

| Supplier | Location | Lot | Crude Source |
|---|---|---|---|
| Parco | Athens, NY | - | Meni-Mota |
| Petro-Canada | Oakville, Ont. | 220 | Western Canadian |

AC-10

| Supplier | Location | Lot | Crude Source |
|---|---|---|---|
| Parco | Athens, NY | 16 | Meni-Mota |
| Petro-Canada | Montreal, Que | 12 | Venezuelan Canadian |

AC-15

| Supplier | Location | Lot | Crude Source |
|---|---|---|---|
| Marathon | Tonawanda, NY | 14 | Mid-Continent and Canadian |
| NoCo Energy | Tonwanada, NY | 6 | Western Canadian |
| Petro-Canada | Oakville, Ont. | 240 | Western Canadian |
| Shell Canada | Hamilton, Ont. | 1 | Venezuelan |
| United Refining | Warren, PA | 8 | Canadian |
| Warden | Pittsford, NY | 34 | Canadian |

AC-20

| Supplier | Location | Lot | Crude Source |
|---|---|---|---|
| Atlantic Refining | Philadelphia, PA | 60 | Merey, Bachaquero |
| Chevron | Perth Amboy, NJ | 19 | Mayan Boscan |
| Cibro | Albany, NY | 36 | Boscan |
| Exxon | Linden, NJ | 21 | Mayan |
| Mantua | Paulsboro, NJ | 28 | Western Venezuelan |
| Marathon | Tonawanda, NY | 15 | Mid-Continent and Canadian |
| Parco | Athens, NY | 17 | Meni-Mota, Tijuana Pesada |
| Peckham Materials | Stamford, CT | 28 | Venezuelan |
| United Refining | Warren, PA | 14 | Canadian |
| Warden | Pittsford, NY | 27 | Canadian |
| West Bank Oil | Perth, Amboy, NJ | 8 | Venezuelan |

85/100

| Supplier | Location | Lot | Crude Source |
|---|---|---|---|
| Esso-Canada | Montreal, Que. | 1 | Venezuelan, Canadian |
| Petro Canada | Montreal, Que. | 13 | Venezuelan, Canadian |
| Shell Canada | Montreal, Que. | 9 | Canadian, Mexican |
| Ultramar | Montreal, Que. | 3 | Venezuelan |

III. Test Performed

A. Tests required by Department of Transportation Specification: (all tests not required on all items of asphalt cement)

1. Viscosity @ 140°F, Absolute, (AASHTO T202)
2. Viscosity @ 275°F, Kinematic, (AASHTO T201)
3. Penetration @77°F, (AASHTO T49)
4. Ductility @ 39.2°F, (AASHTO T51)
5. Flash Point, Cleveland Open Cup, (AASHTO T48)
6. Solubility in Trichloroethylene, (AASHTO T44)
7. % Loss on Thin Film Oven Test Residue, (AASHTO T179)
8. Penetration @77°F on Thin Film Oven Test Residue (AASHTO T49)
9. Penetration @ 77°F Ratio (% of Original) between the Thin Film Oven Test Residue and the Penetration @ 77°F on the original sample.
10. Viscosity @ 140°F, Absolute on Thin Film Oven Test Residue (AASHTO T202)
11. Ductility @ 77°F on Thin Film Oven Test Residue (AASHTO T51)

B. Additional tests not required by Department of Transportation Specifications:

1. Penetration @ 39.2°F (AASHTO T49)
2. Penetration Ratio: 39.2°F/77°F
3. Ductility @ 77°F, (AASHTO T51)
4. Specific Gravity @ 77°F (AASHTO T228)
5. Softening Point, Ethylene Glycol (AASHTO T53)
6. Viscosity @ 275°F, Kinematic, on Thin Film Oven Test Residue (AASHTO T201)
7. Ductility @ 60°F on Thin Film Oven Test Residue (AASHTO T51)
8. Viscosity @ 140°F, Absolute, Ratio, between viscosity @ 140°F, Absolute on Thin Film Oven Test Residue Sample and the original sample.
9. A Settling Test to Evaluate the Relative Degree of Dispersion of Asphaltenes.
10. Separation of Asphalt into Four Fractions, (Modified Method of ASTM D 4124-84).

C. A Penetration Viscosity Number (PVN) and a Penetration Index Number (PIN) has been computed for each asphalt cement sample.

## IV. Test Data and Sample Identification Forms

On the following pages are the Standard Test Report and Sample Identification Forms used for this project.

| PRIMARY SOURCE | LOCATION |
| --- | --- |
| CRUDE SOURCE | SAMPLED AT |
| SAMPLED BY | DATE SAMPLED |
| ITEM NO. | GRADE TYPE |
| LOT NO. | DATE OF CERTIFICATION |

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| | |
|---|---|
| | TEST NO. |
| PRIMARY SOURCE | LOCATION |
| LOT NO. | ITEM NO. / GRADE TYPE |

| CRUDE SOURCE | AASHTO | RESULTS |
|---|---|---|
| 1. Viscosity Ratio @ 140°F | | |
| a.) Viscosity of Original Sample, (poises) | T 202 | |
| 2. Viscosity @ 275°F, Centistokes | T 202 | |
| 3. Penetration @ 77°F, 100g., 5 sec. | T 201 | |
| 4. Penetration @ 39.2°F, 200g., 60 sec. | T 49 | |
| 5. Penetration Ratio (39.2°F/77°F) 100 | | |
| 6. Ductility @ 39.2°F, 1 cm/min., cm. | T 51 | |
| 7. Ductility @ 77°F, 5cm/min., cm. | T 51 | |
| 8. Flash Point C.O.C., F | T 48 | |
| 9. Solubility in Trichloroethylene | T 44 | |
| 10. Loss on Heating T.F.O.T., Percent, 325F @ 5 Hrs. | T 179 | |
| 11. Specific Gravity @ 77°F | T 228 | |
| 12. Ductility @ 60°F, T.F.O.T., 5cm/min., cm. | T 51 | |
| 13. Ductility @ 77°F, T.F.O.T., 5cm/min., cm. | T 51 | |
| 14. Penetration @ 77°F, T.F.O.T., 100g., 5 sec. | T 49 | |
| a.) Percent of Original | | |
| 15. Viscosity @ 275°F After T.O.F.T. (cst) | T 201 | |
| 16. Penetration Viscosity Number, PVN | | |
| 17. Softening Point, Ethylene Glycol, °F | T 53 | |
| 18. Penetration Index Number, PIN | | |

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| | |
|---|---|
| | TEST NO. |
| PRIMARY SOURCE | LOCATION |
| LOT NO. | ITEM NO. / GRADE TYPE |
| CRUDE SOURCE | |

ASPHALT COMPOSITION ANALYSIS

| | |
|---|---|
| ASPHALTENES, % | |
| SATURATES, % | |
| NAPHTHENE AROMATICS, % | |
| POLAR AROMATICS, % | |

A Settling Test to Evaluate the Relative Degree of Dispersion of Asphaltenes

| | |
|---|---|
| SETTLEMENT TIME, MINUTES | |

V. NEW YORK STATE DEPARTMENT OF TRANSPORTATION SPECIFICATIONS FOR ASPHALT CEMENT

TABLE 702-1

ASPHALT CEMENTS FOR PAVING

| MATERIAL DESIGNATION | 702-0100 | | 702-0200 | | 702-0300 | | 702-0400 | | 702-0500 | |
|---|---|---|---|---|---|---|---|---|---|---|
| VISCOSITY GRADE | AC-2.5 | | AC -5 | | AC-10 | | AC-15 | | AC-20 | |
| Test Requirements | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. | Min. | Max. |
| Viscosity 140°F (60 C), P | 200 | 300 | 400 | 600 | 800 | 1200 | 1200 | 1800 | 1600 | 2400 |
| Viscosity 275F(135 C), cSt | 125 | — | 175 | — | 250 | — | 275 | — | 300 | — |
| Penetration 77F (25C),100g, 5s | 200 | 325 | 120 | 200 | 70 | 120 | 60 | 100 | 60 | 100 |
| Flash Point COC,°F(C) | 325(163) | | 350(177) | | 425(219) | | 435(225) | | 450(232) | |
| Solubility in Trichloroethylene, % | 99.0 | | 99.0 | | 99.0 | | 99.0 | | 99.0 | |
| Tests on Residue from Thin Film Oven Test | | | | | | | | | | |
| Viscosity, 140°F(60C), P | — | 1250 | — | 2500 | — | 5000 | — | 7500 | — | 10,000 |
| Ductility, 77°F(25C) 5 cm/min., cm | 100 | — | 100 | — | 75 | — | 60 | — | 50 | — |
| TYPICAL USES (intended only as a general information guide) | Recycle Mix | | Hot plant mix very cold climate. Recycle Mix. | | Hot plant mix cold climate. Recycle Mix. | | Hot plant mix moderate climate. | | Hot plant mix moderate climate. Sheet mixes. Open graded surface course mixes. | |

TABLE 702-2

MISCELLANEOUS ASPHALT CEMENTS

| MATERIAL DESIGNATION | 702-0600 | |
|---|---|---|
| GRADE | 85/100 | |
| TEST REQUIREMENTS | Min | Max |
| Penetration,77F(25C), 100g, 5s | 85 | 100 |
| Viscosity,275F(135C), cSt | 280 | — |
| Flash Point, COC, F | 450 | — |
| Solubility in trichloroethylene, % | 99.5 | — |
| Ductility, 39.2F(4C), 1cm/min., cm | 6 | — |
| Tests on residue from Thin-film Oven Test (AASHTO T179) | | |
| Loss on Heating, 325F, 5h, % | — | .85 |
| Penetration, % original | 47 | — |
| Ductility, 77F(25C), 5cm/min., cm | 75 | — |
| Typical Uses | Hot plant mix moderate climate | |

SPECIFICATION
CHEVRON
ASPHALT FLUX FOR RECYCLING

| TEST REQUIREMENTS | MIN | MAX |
|---|---|---|
| Viscosity, 140F(60C), Poises | 600 | 800 |
| Viscosity, 275F(135C), cst | 200 | - |
| Penetration, 77F(25C), 100g., 5 sec. | 140 | 190 |
| Flash Point, C.O.C.,°F | 350 | - |
| Solubility in Trichloroethylene, % | 99.0 | - |
| Tests on Residue from Thin Film Oven Test: | | |
| Viscosity, 140F(60C), Poises | - | 3200 |
| Ductility, 77F(25C), 5cm/min., cm. | 100 | - |

SPECIFICATION
CIBRO
ASPHALT FLUX FOR RECYCLING

| TEST REQUIREMENTS | MIN | MAX |
|---|---|---|
| Viscosity, 140F(60C), Poises | 800 | 1200 |
| Viscosity, 275F(135F), cst | 175 | - |
| Penetration, 77F(25C), 100g., 5 sec. | 125 | 175 |
| Flash Point, C.O.C., °F | 400 | -- |
| Solubility in Trichloroethylene, % | 99.0 | - |
| Test on Residue from Thin Film Oven Test: | | |
| Viscosity, 140F(60C), Poises | - | 4000 |
| Ductility, 77F(25C), 5cm/min., cm. | 75 | - |

SPECIFICATION
MARATHON
ASPHALT FLUX FOR RECYCLING

| TEST REQUIREMENTS | MIN | MAX |
|---|---|---|
| Viscosity, 140F(60C), Poises | 450 | 650 |
| Viscosity, 275F(135C), cst | 175 | - |
| Penetration, 77F(25C), 100g., 5 sec. | 150 | 200 |
| Flash Point, C.O.C., °F | 350 | - |
| Solubility in Trichloroethylene, % | 99.0 | - |
| Tests on Residue from Thin Film Oven Test: | | |
| Viscosity, 140F(60C), Poises | - | 2500 |
| Ductility, 77F(25C), 5cm/min., cm. | 100 | - |

## VI. Summary of Test Results

Test results for all twenty-eight asphalt cement samples met New York State Department of Transportation Specification requirements. The following exceptions are noted below:

A. Parco, Athens, NY
#702-0200, AC-5 Lot - Meni-Mota

Viscosity @ 140°F, Absolute 624 poises
Specification: 460 to 600 poises

B. United Refining, Warren, PA
#702-0400, AC-15 Lot 8 Canadian

Penetration @ 77°F, 57
Specification: 60 to 100

C. United Refining, Warren, PA
#702-0500, AC-20 Lot 14 Canadian

Penetration @ 77°F, 59
Specification 60 to 100

Warden Asphalt, Pittsford, NY
#702-0500, AC-20, Lot 27 Canadian

Penetration @ 77°F, 59
Specification 60 to 100

Esso Canada, Montreal, Que.
#702-0600, 85/100 Lot 1 Venezuelan Canadian

Penetration @ 77°F, 76
Specification 85 to 100

## VII. Test Results

On the following pages is a tabulation of all test results. The column headed by the name of the test contains the test result determined by the Materials Bureau. The column headed by "Comparative Results" contains the test result provided by the supplier for the test indicated in the column immediately to the left.

| 1986 ASP | MONITOR | | TRATION 9.2°F | COMPARATIVE RESULTS | PENETRATION RATIO 39.2°/77°F | COMPARATIVE RESULTS |
|---|---|---|---|---|---|---|
| AC | SUPPLI | | 25 | * | 38.2 | * |
| FLUX | CHEVRO | | 53 | 47 | 39.6 | 34.6 |
| FLUX | CIBRO | | 49 | 49 | 30.8 | 29.3 |
| FLUX | MARATI | | | | | |
| | | | 56 | 48 | 36.2 | 32.0 |
| | | | 3.3 | 1.4 | 4.7 | 3.7 |
| | | | | | | |
| | | | 53 | * | 32.1 | * |
| 5 | PARCO | | 45 | * | 28.3 | * |
| 5 | PETRO | | | | | |
| | | | 49 | — | 30.2 | — |
| | | | 5.7 | — | 2.7 | — |
| | | | | | | |
| | | | 38 | * | 33.0 | * |
| 10 | PARC | | 32 | 40 | 33.7 | 43.0 |
| 10 | PETRO | | | | | |
| | | | 35 | — | 33.4 | — |
| | | | 4.2 | — | 0.5 | — |
| | | | | | | |
| | | | 28 | 29 | 30.8 | 32.2 |
| 15 | MARI | | 27 | * | 32.5 | * |
| 15 | NOCO | | 26 | * | 30.6 | * |
| 15 | PETR | | 30 | * | 34.9 | * |
| 15 | SHEL | | 18 | 16 | 31.6 | 25.4 |
| 15 | UNIT | | 18 | * | 28.1 | * |
| 15 | WAR | | | | | |
| | | | 25 | 23 | 31.4 | 28.8 |
| | | | 5.2 | 9.2 | 2.3 | 4.8 |
| | | | | | | |
| | | | 28 | 32 | 35.9 | 39.0 |
| 20 | ATLA | | 34 | * | 38.2 | * |
| 20 | CHE | | 34 | 34 | 36.2 | 35.8 |
| 20 | CIB | | 21 | * | 30.9 | * |
| 20 | EXY | | 29 | * | 37.2 | * |
| 20 | MA | | 23 | 21 | 32.9 | 29.2 |
| 20 | MA | | 28 | * | 36.4 | * |
| 20 | PA | | 29 | * | 37.7 | * |
| 20 | PEC | | 23 | 17 | 39.0 | 26.2 |
| 20 | UN | | 23 | * | 39.0 | * |
| 20 | WA | | 32 | 30 | 42.7 | 37.0 |
| 20 | WES | | | | | |
| | | | 28 | 27 | 37.0 | 33.4 |
| | | | 4.6 | 7.4 | 3.1 | 5.5 |
| | | | | | | |
| | | | 26 | 34 | 34.2 | 41.0 |
| 85/100 | ESS | | 29 | 43 | 33.7 | 48.3 |
| 85/100 | PET | | 29 | 30 | 34.1 | 35.3 |
| 85/100 | SHI | | 30 | 33 | 35.3 | 36.7 |
| 85/100 | ULT | | | | | |
| | | | 29 | 35 | 34.3 | 40.3 |
| | | | 1.7 | 5.6 | 0.7 | 5.8 |

* RESULTS NOT GIVEN

## VII. Test Results

On the following pages is a tabulation of all test results. The column headed by the name of the test contains the test result determined by the Materials Bureau. The column headed by "Comparative Results" contains the test result provided by the supplier for the test indicated in the column immediately to the left.

| 1986 ASPHALT CEMENT MONITOR PROGRAM | | | ABSOLUTE | | KINEMATIC | | | | | | PENETRATION | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CRUDE | VISCOSITY | COMPARATIVE | VISCOSITY | COMPARATIVE | PENETRATION | COMPARATIVE | PENETRATION | COMPARATIVE | RATIO | COMPARATIVE |
| AC | SUPPLIER - LOCATION - LOT | SOURCE | @ 140°F | RESULTS | @ 275°F | RESULTS | @ 77°F | RESULTS | @ 39.2°F | RESULTS | 39.2°/77°F | RESULTS |
| FLUX | CHEVRON, PERTH AMBOY 18 | MAYAN BOSCAN | 774 | 735 | 286 | 278 | 170 | 170 | 65 | * | 38.2 | * |
| FLUX | CIBRO, ALBANY 35 | BOSCAN | 1138 | 1101 | 334 | 321 | 134 | 136 | 53 | 47 | 39.6 | 34.6 |
| FLUX | MARATHON, TONAWANDA 16 | MID-CONTINENT CANADIAN | 607 | 632 | 232 | 227 | 159 | 167 | 49 | 49 | 30.8 | 29.3 |
| | $\bar{X}$ | | 840 | 823 | 284 | 275 | 154 | 158 | 56 | 48 | 36.2 | 32.0 |
| | $\sigma$ | | 271.5 | 246.5 | 51.0 | 47.1 | 18.4 | 18.8 | 8.3 | 1.4 | 4.7 | 3.7 |
| 5 | PARCO, ATHENS — | MENI-MOTA | 624 | 658 | 235 | 228 | 165 | 161 | 53 | * | 32.1 | * |
| 5 | PETRO-CAN., OAKVILLE 220 | WESTERN CANADIAN | 561 | 574 | 224 | 225 | 159 | 163 | 45 | * | 28.3 | * |
| | $\bar{X}$ | | 593 | 616 | 230 | 227 | 162 | 162 | 49 | — | 30.2 | — |
| | $\sigma$ | | 44.5 | 59.4 | 7.8 | 2.1 | 4.2 | 1.4 | 5.7 | — | 2.7 | — |
| 10 | PARCO, ATHENS 16 | MENI-MOTA | 1139 | 1158 | 302 | 302 | 115 | 110 | 38 | * | 33.0 | * |
| 10 | PETRO-CAN., MONTREAL 12 | VENEZUELAN CANADIAN | 1175 | 1158 | 307 | 302 | 95 | 93 | 32 | 40 | 33.7 | 43.0 |
| | $\bar{X}$ | | 1157 | 1158 | 305 | 302 | 105 | 102 | 35 | — | 33.4 | — |
| | $\sigma$ | | 25.5 | — | 3.5 | — | 14.1 | 12.0 | 4.2 | — | 0.5 | — |
| 15 | MARATHON, TONAWANDA 14 | MID-CONTINENT CANADIAN | 1425 | 1447 | 340 | 338 | 91 | 90 | 28 | 29 | 30.8 | 32.2 |
| 15 | NOCO ENERGY, TONAWANDA 6 | WESTERN CANADIAN | 1439 | 1546 | 346 | * | 83 | 70 | 27 | * | 32.5 | * |
| 15 | PETRO-CAN., OAKVILLE 240 | WESTERN CANADIAN | 1453 | 1405 | 343 | 351 | 85 | 87 | 26 | * | 30.6 | * |
| 15 | SHELL-CAN., HAMILTON 1 | VENEZUELAN | 1753 | * | 378 | * | 86 | * | 30 | * | 34.9 | * |
| 15 | UNITED REF., WARREN, PA. 8 | CANADIAN | 1572 | 1470 | 316 | 315 | 57 | 63 | 18 | 16 | 31.6 | 25.4 |
| 15 | WARDEN, PITTSFORD 34 | CANADIAN | 1510 | 1509 | 339 | * | 64 | 66 | 18 | * | 28.1 | * |
| | $\bar{X}$ | | 1525 | 1475 | 344 | 335 | 78 | 75 | 25 | 23 | 31.4 | 28.8 |
| | $\sigma$ | | 124.1 | 54.6 | 19.9 | 18.2 | 13.7 | 12.4 | 5.2 | 9.2 | 2.3 | 4.8 |
| 20 | ATLANTIC, PHILADELPHIA PA. 60 | MEREY, BACHAQUERO | 1865 | 1812 | 373 | 368 | 78 | 82 | 28 | 32 | 35.9 | 39.0 |
| 20 | CHEVRON, PERTH AMBOY 19 | MAYAN BOSCAN | 2145 | 1966 | 458 | 442 | 89 | 87 | 34 | * | 38.2 | * |
| 20 | CIBRO, ALBANY 36 | BOSCAN | 1866 | 1779 | 429 | 410 | 94 | 95 | 34 | 34 | 36.2 | 35.8 |
| 20 | EXXON, LINDEN, N.J. 21 | NORTH SLOPE MAYA, MEX. | 2026 | 1810 | 393 | 413 | 68 | 67 | 21 | * | 30.9 | * |
| 20 | MANTUA, PAULSBORO, N.J. 28 | WESTERN VENEZUELAN | 2136 | 2114 | 407 | 396 | 78 | 77 | 29 | * | 37.2 | * |
| 20 | MARATHON, TONAWANDA 15 | MID-CONTINENT CANADIAN | 2041 | 2077 | 404 | 390 | 70 | 72 | 23 | 21 | 32.9 | 29.2 |
| 20 | PARCO, ATHENS 17 | MENI-MOTA TIJUNA PESADA | 1861 | 1864 | 382 | 388 | 77 | 82 | 28 | * | 36.4 | * |
| 20 | PECKHAM, STAMFORD, CT. 28 | VENEZUELAN | 2114 | 2062 | 420 | * | 77 | 77 | 29 | * | 37.7 | * |
| 20 | UNITED REF., WARREN, PA. 14 | CANADIAN | 1746 | 1652 | 377 | 380 | 59 | 65 | 23 | 17 | 39.0 | 26.2 |
| 20 | WARDEN, PITTSFORD 27 | CANADIAN | 1751 | 1726 | 378 | * | 59 | 66 | 23 | * | 39.0 | * |
| 20 | WEST BANK, PERTH AMBOY 8 | VENEZUELAN | 2138 | 2040 | 426 | 425 | 75 | 81 | 32 | 30 | 42.7 | 37.0 |
| | $\bar{X}$ | | 1972 | 1900 | 404 | 401 | 75 | 77 | 28 | 27 | 37.0 | 33.4 |
| | $\sigma$ | | 157.2 | 158.4 | 26.9 | 23.3 | 10.8 | 9.4 | 4.6 | 7.4 | 3.1 | 5.5 |
| 85/100 | ESSO REF., MONTREAL 1 | VENEZUELAN CANADIAN | 1560 | 1492 | 364 | 364 | 76 | 83 | 26 | 34 | 34.2 | 41.0 |
| 85/100 | PETRO-CAN., MONTREAL 13 | VENEZUELAN CANADIAN | 1275 | 1301 | 320 | 311 | 86 | 89 | 29 | 43 | 33.7 | 48.3 |
| 85/100 | SHELL-CAN, MONTREAL 9 | CANADIAN MEXICAN | 1195 | 1161 | 318 | 302 | 85 | 85 | 29 | 30 | 34.1 | 35.3 |
| 85/100 | ULTRAMAR, MONTREAL 3 | VENEZUELAN | 1413 | 1401 | 334 | 327 | 85 | 90 | 30 | 33 | 35.3 | 36.7 |
| | $\bar{X}$ | | 1361 | 1339 | 334 | 326 | 83 | 87 | 29 | 35 | 34.3 | 40.3 |
| | $\sigma$ | | 160.5 | 141.9 | 21.2 | 27.4 | 4.7 | 3.3 | 1.7 | 5.6 | 0.7 | 5.8 |

* RESULTS NOT GIVEN

| 1986 ASPH MONITOR | | T. | | T.F.O.T. | |
|---|---|---|---|---|---|
| AC | SUPPLIE | ITY °F | COMPARATIVE RESULTS | VISCOSITY RATIO | COMPARATIVE RESULTS |
| FLUX | CHEVRO | 4 | 2431 | 3.18 | 3.31 |
| FLUX | CIBRO | 96 | 3035 | 2.72 | 2.76 |
| FLUX | MARATH | 33 | 1263 | 2.11 | 2.00 |
| | | | | | |
| | | 81 | 2243 | 2.67 | 2.69 |
| | | 0.2 | 900.8 | 0.54 | 0.66 |
| | | | | | |
| | | 3 | 1442 | 2.52 | 2.19 |
| 5 | PARCO | 8 | 1202 | 1.94 | 2.09 |
| 5 | PETRO- | | | | |
| | | 31 | 1322 | 2.23 | 2.14 |
| | | 2.9 | 169.7 | 0.41 | 0.07 |
| | | | | | |
| | | 21 | 2636 | 2.39 | 2.28 |
| 10 | PARCO | 66 | 2685 | 2.52 | 2.32 |
| 10 | PETRO- | | | | |
| | | 44 | 2661 | 2.46 | 2.30 |
| | | 3.2 | 34.6 | 0.09 | 0.03 |
| | | | | | |
| | | 87 | 3278 | 2.31 | 2.27 |
| 15 | MARATH | 19 | * | 2.38 | * |
| 15 | NOCO | 75 | 3055 | 1.98 | 2.17 |
| 15 | PETRO- | 14 | * | 2.58 | * |
| 15 | SHELL- | 04 | 3620 | 2.48 | 2.46 |
| 15 | UNITED | 60 | * | 2.75 | * |
| 15 | WARDE | | | | |
| | | 93 | 3318 | 2.41 | 2.30 |
| | | 7.6 | 284.6 | 0.26 | 0.15 |
| | | | | | |
| | | 491 | 4749 | 2.41 | 2.62 |
| 20 | ATLAN | 03 | 6014 | 3.08 | 3.06 |
| 20 | CHEVR | 89 | 5053 | 2.83 | 2.84 |
| 20 | CIBRO | 06 | 3683 | 2.37 | 2.03 |
| 20 | EXXO | 283 | 4585 | 2.47 | 2.17 |
| 20 | MAN | 74 | 4247 | 2.34 | 2.04 |
| 20 | MARA | 49 | 4484 | 2.50 | 2.41 |
| 20 | PARC | 87 | * | 2.64 | * |
| 20 | PECK | 02 | 4056 | 2.35 | 2.46 |
| 20 | UNI | 75 | * | 2.44 | * |
| 20 | WAR | 566 | 5858 | 3.07 | 2.87 |
| 20 | WES | | | | |
| | | 130 | 4748 | 2.59 | 2.50 |
| | | 45.5 | 781.7 | 0.28 | 0.38 |
| | | | | | |
| | | 910 | * | 2.51 | * |
| 85/100 | ESS | 415 | 3578 | 2.68 | 2.75 |
| 85/100 | PETR | 228 | 2998 | 2.70 | 2.58 |
| 85/100 | SHEL | 603 | 2557 | 2.55 | 1.83 |
| 85/100 | ULTR | | | | |
| | | 5539 | 3044 | 2.61 | 2.39 |
| | | 290.9 | 512.1 | 0.09 | 0.49 |

* RESULTS NOT GIVEN

| 1986 ASPHALT CEMENT MONITOR PROGRAM | | | CRUDE | T.F.O.T. LOSS | COMPARATIVE | T.F.O.T. DUCTILITY | COMPARATIVE | T.F.O.T. DUCTILITY | COMPARATIVE | T.F.O.T. VISCOSITY | COMPARATIVE | T.F.O.T. VISCOSITY | COMPARATIVE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AC | SUPPLIER - LOCATION - LOT | | SOURCE | % | RESULTS | @60°F | RESULTS | @77°F | RESULTS | @140°F | RESULTS | RATIO | RESULTS |
| FLUX | CHEVRON, PERTH AMBOY | 18 | MAYAN BOSCAN | 0.757 | * | 99 | * | 150+ | 110+ | 2464 | 2431 | 3.18 | 3.31 |
| FLUX | CIBRO, ALBANY | 35 | BOSCAN | 0,687 | 0.730 | 150+ | 150+ | 150+ | 150+ | 3096 | 3035 | 2.72 | 2.76 |
| FLUX | MARATHON, TONAWANDA | 16 | MID CONTINENT CANADIAN | 0.131 | 0.160 | 150+ | 150+ | 150+ | 150+ | 1283 | 1263 | 2.11 | 2.00 |
| | | | | | | | | | | | | | |
| | $\bar{x}$ | | | 0.525 | 0.445 | 133 | 150+ | 150+ | —— | 2281 | 2243 | 2.67 | 2.69 |
| | $\sigma$ | | | 0.343 | 0.403 | 29.4 | —— | —— | —— | 920.2 | 900.8 | 0.54 | 0.66 |
| | | | | | | | | | | | | | |
| 5 | PARCO, ATHENS | —— | MENI-MOTA | 0.234 | 0.190 | 150+ | * | 150+ | 150+ | 1573 | 1442 | 2.52 | 2.19 |
| 5 | PETRO-CAN., OAKVILLE | 220 | WESTERN CANADIAN | +0.055 | +0.030 | 150+ | * | 150+ | 150+ | 1088 | 1202 | 1.94 | 2.09 |
| | | | | | | | | | | | | | |
| | $\bar{x}$ | | | 0.117 | 0.095 | 150+ | —— | 150+ | 150+ | 1331 | 1322 | 2.23 | 2.14 |
| | $\sigma$ | | | 0.165 | 0.134 | —— | —— | —— | —— | 342.9 | 169.7 | 0.41 | 0.07 |
| | | | | | | | | | | | | | |
| 10 | PARCO, ATHENS | 16 | MENI-MOTA | 0.168 | 0.130 | 150+ | * | 150+ | 150+ | 2721 | 2636 | 2.39 | 2.28 |
| 10 | PETRO-CAN., MONTREAL | 12 | VENEZUELAN CANADIAN | 0.030 | 0.070 | 109 | 140+ | 150+ | 140+ | 2966 | 2685 | 2.52 | 2.32 |
| | | | | | | | | | | | | | |
| | $\bar{x}$ | | | 0.099 | 0.100 | 130 | —— | 150+ | —— | 2844 | 2661 | 2.46 | 2.30 |
| | $\sigma$ | | | 0.098 | 0.042 | 29.0 | —— | —— | —— | 173.2 | 34.6 | 0.09 | 0.03 |
| | | | | | | | | | | | | | |
| 15 | MARATHON, TONAWANDA | 14 | MID-CONTINENT CANADIAN | 0.141 | 0.110 | 150+ | 150+ | 150+ | 150+ | 3287 | 3278 | 2.31 | 2.27 |
| 15 | NOCO ENERGY, TONAWANDA | 6 | WESTERN CANADIAN | 0.118 | * | 110 | * | 150+ | * | 3419 | * | 2.38 | * |
| 15 | PETRO-CAN., OAKVILLE | 240 | WESTERN CANADIAN | +0.040 | +0.025 | 150+ | * | 150+ | 150+ | 2875 | 3055 | 1.98 | 2.17 |
| 15 | SHELL-CAN., HAMILTON | 1 | VENEZUELAN | 0.259 | * | 78.75 | * | 150+ | * | 4514 | * | 2.58 | * |
| 15 | UNITED REF., WARREN, PA. | 8 | CANADIAN | +0.010 | +0.020 | 15.50 | 19 | 150+ | 120+ | 3904 | 3620 | 2.48 | 2.46 |
| 15 | WARDEN, PITTSFORD | 34 | CANADIAN | 0.364 | * | 14.25 | * | 150+ | * | 4160 | * | 2.75 | * |
| | | | | | | | | | | | | | |
| | $\bar{x}$ | | | 0.147 | 0.037 | 86.4 | 84.5 | 150+ | —— | 3693 | 3318 | 2.41 | 2.30 |
| | $\sigma$ | | | 0.144 | 0.064 | 61.5 | 92.6 | —— | —— | 607.6 | 284.6 | 0.26 | 0.15 |
| | | | | | | | | | | | | | |
| 20 | ATLANTIC, PHILADELPHIA, PA. | 60 | MEREY BACHAQUERO | 0.019 | 0.025 | 31.50 | 58 | 150+ | * | 4491 | 4749 | 2.41 | 2.62 |
| 20 | CHEVRON, PERTH AMBOY | 19 | MAYAN BOSCAN | 0.329 | * | 66 | * | 150+ | 100+ | 6603 | 6014 | 3.08 | 3.06 |
| 20 | CIBRO, ALBANY | 36 | BOSCAN | 0.551 | 0.610 | 150+ | 148 | 150+ | 150+ | 5289 | 5053 | 2.83 | 2.84 |
| 20 | EXXON, LINDEN, N.J. | 21 | NORTH SLOPE MAYA, MEX. | 0.097 | 0.090 | 34 | 66 | 150+ | 150+ | 4806 | 3683 | 2.37 | 2.03 |
| 20 | MANTUA, PAULSBORO, N.J. | 28 | WESTERN VENEZUELAN | 0.174 | 0.200 | 136 | * | 150+ | 110+ | 5283 | 4585 | 2.47 | 2.17 |
| 20 | MARATHON, TONAWANDA | 15 | MID-CONTINENT CANADIAN | 0.110 | 0.110 | 92.50 | 150+ | 150+ | 150+ | 4774 | 4247 | 2.34 | 2.04 |
| 20 | PARCO, ATHENS | 17 | MENI-MOTA TIJUANA PESADA | 0.080 | 0.080 | 135 | * | 150+ | 150+ | 4649 | 4484 | 2.50 | 2.41 |
| 20 | PECKHAM, STAMFORD, CT. | 28 | VENEZUELAN | 0.178 | * | 75.25 | * | 150+ | * | 5587 | * | 2.64 | * |
| 20 | UNITED REF., WARREN, PA. | 14 | CANADIAN | 0.018 | +0.020 | 50.25 | 45 | 150+ | 120+ | 4102 | 4056 | 2.35 | 2.46 |
| 20 | WARDEN, PITTSFORD | 27 | CANADIAN | 0.048 | * | 26.50 | * | 150+ | * | 4275 | * | 2.44 | * |
| 20 | WEST BANK, PERTH AMBOY | 8 | VENEZUELAN | 0.144 | 0.128 | 24.25 | 23 | 150+ | 100+ | 6566 | 5858 | 3.07 | 2.87 |
| | | | | | | | | | | | | | |
| | $\bar{x}$ | | | 0.159 | 0.155 | 74.7 | 81.7 | 150+ | —— | 5130 | 4748 | 2.59 | 2.50 |
| | $\sigma$ | | | 0.157 | 0.194 | 47.4 | 54.2 | —— | —— | 845.5 | 781.7 | 0.28 | 0.38 |
| | | | | | | | | | | | | | |
| 85/100 | ESSO REF., MONTREAL | 1 | VENEZUELAN CANADIAN | 0.073 | 0.070 | 63.25 | 150+ | 150+ | 150+ | 3910 | * | 2.51 | * |
| 85/100 | PETRO-CAN., MONTREAL | 13 | VENEZUELAN CANADIAN | 0.026 | 0.040 | 76.50 | 95 | 150+ | 140+ | 3415 | 3578 | 2.68 | 2.75 |
| 85/100 | SHELL-CAN., MONTREAL | 9 | CANADIAN MEXICAN | +0.041 | +0.050 | 47.25 | 35 | 150+ | 80 | 3228 | 2998 | 2.70 | 2.58 |
| 85/100 | ULTRAMAR, MONTREAL | 3 | VENEZUELAN | 0.033 | 0.029 | 98.75 | 120 | 150+ | 150+ | 3603 | 2557 | 2.55 | 1.83 |
| | | | | | | | | | | | | | |
| | $\bar{x}$ | | | 0.033 | 0.035 | 71.4 | 100.0 | 150+ | —— | 3539 | 3044 | 2.61 | 2.39 |
| | $\sigma$ | | | 0.030 | 0.029 | 21.8 | 48.8 | —— | —— | 290.9 | 512.1 | 0.09 | 0.49 |

* RESULTS NOT GIVEN

| 1986 ASPHA | | CIFIC | | C.O.C. | |
|---|---|---|---|---|---|
| MONITOR | | VITY | COMPARATIVE | FLASH | COMPARATIVE |
| AC | SUPPLIE | T°F | RESULTS | POINT, °F | RESULTS |
| FLUX | CHEVRO | 027 | 1.024 | 495 | 495 |
| FLUX | CIBRO, | 027 | 1.027 | 535 | 475 |
| FLUX | MARATH | 020 | 1.022 | 565 | 580 |
| | | | | | |
| | | 025 | 1.024 | 532 | 517 |
| | | 004 | 0.003 | 35.1 | 55.8 |
| | | | | | |
| | | 018 | 1.018 | 530 | 525 |
| 5 | PARCO, | 017 | 1.019 | 565 | 608 |
| 5 | PETRO-C | | | | |
| | | 018 | 1.019 | 548 | 567 |
| | | 001 | 0.001 | 24.7 | 58.7 |
| | | | | | |
| | | .021 | 1.021 | 525 | 540 |
| 10 | PARCO | .022 | 1.022 | 540 | 585 |
| 10 | PETRO- | | | | |
| | | .022 | 1.022 | 533 | 563 |
| | | .001 | 0.001 | 10.6 | 31.8 |
| | | | | | |
| | | .026 | 1.024 | 550 | 580 |
| 15 | MARA | .023 | * | 580 | * |
| 15 | NOCO | .023 | 1.023 | 590 | 622 |
| 15 | PETRO | .019 | * | 545 | * |
| 15 | SHELL | .024 | 1.022 | 620 | 615 |
| 15 | UNITE | .012 | * | 615 | * |
| 15 | WARC | | | | |
| | | 1.021 | 1.023 | 583 | 606 |
| | | 0.005 | 0.001 | 31.6 | 22.5 |
| | | | | | |
| | | 1.024 | 1.031 | 545 | 550 |
| 20 | ATLA | 1.032 | 1.030 | 500 | 525 |
| 20 | CHEV | 1.030 | 1.030 | 485 | 485 |
| 20 | CIB | 1.028 | 1.026 | 635 | 550+ |
| 20 | EXX | 1.023 | 1.026 | 535 | 555 |
| 20 | MAN | 1.028 | 1.028 | 605 | 600+ |
| 20 | MAR | 1.024 | 1.023 | 535 | 565 |
| 20 | PAR | 1.021 | * | 540 | * |
| 20 | PECK | 1.025 | 1.022 | 595 | 600 |
| 20 | UNI | 1.024 | * | 605 | * |
| 20 | WA | 1.018 | 1.016 | 550 | 560 |
| 20 | WE | | | | |
| | | 1.025 | 1.026 | 557 | — |
| | | 0.004 | 0.005 | 46.9 | — |
| | | | | | |
| | | 1.017 | 1.018 | 610 | 605 |
| 85/100 | ESS | 1.022 | 1.021 | 560 | 590 |
| 85/100 | PET | 1.023 | 1.022 | 595 | 608 |
| 85/100 | SHE | 1.019 | 1.019 | 585 | 618 |
| 85/100 | ULT | | | | |
| | | 1.020 | 1.020 | 588 | 605 |
| | | 0.003 | 0.002 | 21.0 | 11.6 |

* RESULTS NOT GIVEN

| 1986 ASPHALT CEMENT MONITOR PROGRAM | | CRUDE | T.F.O.T. VISCOSITY | COMPARATIVE | T.F.O.T. PENETRATION | COMPARATIVE | T.F.O.T. PENETRATION | COMPARATIVE | SPECIFIC GRAVITY | COMPARATIVE | C.O.C. FLASH | COMPARATIVE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AC | SUPPLIER - LOCATION - LOT | SOURCE | @ 275°F | RESULTS | @ 77°F | RESULTS | RATIO | RESULTS | @ 77°F | RESULTS | POINT, °F | RESULTS |
| FLUX | CHEVRON, PERTH AMBOY 18 | MAYAN BOSCAN | 479 | * | 88 | * | 51.8 | * | 1.027 | 1.024 | 495 | 495 |
| FLUX | CIBRO, ALBANY 35 | BOSCAN | 536 | 528 | 77 | 75 | 57.5 | 55.1 | 1.027 | 1.027 | 535 | 475 |
| FLUX | MARATHON, TONAWANDA 16 | MID-CONTINENT CANADIAN | 316 | 298 | 96 | 95 | 60.4 | 56.9 | 1.020 | 1.022 | 565 | 580 |
| | $\bar{x}$ | | 444 | 413 | 87 | 85 | 56.6 | 56.0 | 1.025 | 1.024 | 532 | 517 |
| | $\sigma$ | | 114.2 | 162.6 | 9.5 | 14.1 | 4.4 | 1.3 | 0.004 | 0.003 | 35.1 | 55.8 |
| 5 | PARCO, ATHENS — | MEXI-MOTA | 336 | 333 | 91 | 93 | 55.2 | 57.8 | 1.018 | 1.018 | 530 | 525 |
| 5 | PETRO-CAN., OAKVILLE 220 | WESTERN CANADIAN | 296 | * | 96 | 96 | 60.4 | 58.9 | 1.017 | 1.019 | 565 | 608 |
| | $\bar{x}$ | | 316 | —— | 94 | 95 | 57.8 | 58.4 | 1.018 | 1.019 | 548 | 567 |
| | $\sigma$ | | 28.3 | —— | 3.5 | 2.1 | 3.7 | 0.8 | 0.001 | 0.001 | 24.7 | 58.7 |
| 10 | PARCO, ATHENS 16 | MEX-MOTA | 441 | 455 | 68 | 66 | 59.1 | 60.0 | 1.021 | 1.021 | 525 | 540 |
| 10 | PETRO-CAN., MONTREAL 12 | VENEZUELAN CANADIAN | 449 | 432 | 58 | 60 | 61.1 | 64.5 | 1.022 | 1.022 | 540 | 585 |
| | $\bar{x}$ | | 445 | 444 | 63 | 63 | 60.1 | 62.3 | 1.022 | 1.022 | 533 | 563 |
| | $\sigma$ | | 5.7 | 16.3 | 7.1 | 4.2 | 1.4 | 3.2 | 0.001 | 0.001 | 10.6 | 31.8 |
| 15 | MARATHON, TONAWANDA 14 | MID CONTINENT CANADIAN | 485 | 460 | 54 | 55 | 59.3 | 61.1 | 1.026 | 1.024 | 550 | 580 |
| 15 | NOCO ENERGY, TONAWANDA 6 | WESTERN CANADIAN | 499 | * | 51 | * | 61.4 | * | 1.023 | * | 580 | * |
| 15 | PETRO-CAN., OAKVILLE 240 | WESTERN CANADIAN | 463 | * | 55 | 54 | 64.7 | 62.1 | 1.023 | 1.023 | 590 | 622 |
| 15 | SHELL-CAN., HAMILTON 1 | VENEZUELAN | 564 | * | 52 | * | 60.5 | * | 1.019 | * | 545 | * |
| 15 | UNITED REF., WARREN, PA. 8 | CANADIAN | 448 | 430 | 37 | 36 | 64.9 | 57.1 | 1.024 | 1.022 | 620 | 615 |
| 15 | WARDEN, PITTSFORD 34 | CANADIAN | 484 | * | 37 | * | 57.8 | * | 1.012 | * | 615 | * |
| | $\bar{x}$ | | 491 | 445 | 48 | 48 | 61.4 | 60.1 | 1.021 | 1.023 | 583 | 606 |
| | $\sigma$ | | 40.3 | 21.2 | 8.4 | 10.7 | 2.9 | 2.6 | 0.005 | 0.001 | 31.6 | 22.5 |
| 20 | ATLANTIC, PHILADELPHIA, PA. 60 | MEXICY BACHAQUERO | 544 | 552 | 51 | 50 | 65.4 | 61.0 | 1.024 | 1.031 | 545 | 550 |
| 20 | CHEVRON, PERTH AMBOY 19 | MAYAN BOSCAN | 748 | * | 53 | * | 59.6 | * | 1.032 | 1.030 | 500 | 525 |
| 20 | CIBRO, ALBANY 36 | BOSCAN | 693 | 662 | 56 | 54 | 59.6 | 56.8 | 1.030 | 1.030 | 485 | 485 |
| 20 | EXXON, LINDEN, NJ. 21 | NORTH SLOPE MAYA, MEX. | 560 | 483 | 42 | 43 | 61.8 | 64.2 | 1.028 | 1.026 | 635 | 550+ |
| 20 | MANTUA, PAULSBORO, NJ. 28 | WESTERN VENEZUELAN | 605 | * | 50 | 51 | 64.1 | 66.2 | 1.023 | 1.026 | 535 | 555 |
| 20 | MARATHON, TONAWANDA 15 | MID CONTINENT CANADIAN | 573 | 545 | 44 | 44 | 62.9 | 61.1 | 1.028 | 1.028 | 605 | 600+ |
| 20 | PARCO, ATHENS 17 | MEXI-MOTA TULKANA PESADA | 566 | 538 | 52 | 51 | 67.5 | 62.2 | 1.024 | 1.023 | 535 | 565 |
| 20 | PECKHAM, STAMFORD, CT. 28 | VENEZUELAN | 614 | * | 50 | * | 64.9 | * | 1.021 | * | 540 | * |
| 20 | UNITED REF., WARREN, PA. 14 | CANADIAN | 531 | 539 | 44 | 38 | 74.6 | 58.5 | 1.025 | 1.022 | 595 | 600 |
| 20 | WARDEN, PITTSFORD 27 | CANADIAN | 532 | * | 42 | * | 71.2 | * | 1.024 | * | 605 | * |
| 20 | WEST BANK, PERTH AMBOY 8 | VENEZUELAN | 661 | 621 | 48 | 49 | 64.0 | 60.5 | 1.018 | 1.016 | 550 | 560 |
| | $\bar{x}$ | | 602 | 563 | 48 | 48 | 65.1 | 61.3 | 1.025 | 1.026 | 557 | —— |
| | $\sigma$ | | 71.0 | 59.5 | 4.7 | 5.3 | 4.6 | 3.0 | 0.004 | 0.005 | 46.9 | —— |
| 85/100 | ESSO REF., MONTREAL 1 | VENEZUELAN CANADIAN | 528 | * | 51 | 50 | 67.1 | 60.2 | 1.017 | 1.018 | 610 | 605 |
| 85/100 | PETRO-CAN., MONTREAL 13 | VENEZUELAN CANADIAN | 481 | 506 | 55 | 52 | 64.0 | 58.4 | 1.022 | 1.021 | 560 | 590 |
| 85/100 | SHELL-CAN., MONTREAL 9 | CANADIAN MEXICAN | 470 | 448 | 56 | 57 | 65.9 | 67.1 | 1.023 | 1.022 | 595 | 608 |
| 85/100 | ULTRAMAR, MONTREAL 3 | VENEZUELAN | 490 | 444 | 54 | 62 | 63.5 | 68.9 | 1.019 | 1.019 | 585 | 618 |
| | $\bar{x}$ | | 492 | 466 | 54 | 55 | 65.1 | 63.7 | 1.020 | 1.020 | 588 | 605 |
| | $\sigma$ | | 25.2 | 34.7 | 2.2 | 5.4 | 1.7 | 5.1 | 0.003 | 0.002 | 21.0 | 11.6 |

* RESULTS NOT GIVEN

| 1986 ASPHAL | | NG | COMPARATIVE | PVN | COMPARATIVE |
|---|---|---|---|---|---|
| MONITOR PR | | °F | RESULTS | | RESULTS |
| AC | SUPPLIER- | | * | -0.097 | -0.145 |
| FLUX | CHEVRON, | | * | -0.148 | -0.194 |
| FLUX | CIBRO, A | | 113 | -0.538 | -0.514 |
| FLUX | MARATHON | | | | |
| | | | 113 | -0.261 | -0.284 |
| | | 5 | —— | 0.241 | 0.200 |
| | | | | | |
| | | ) | * | -0.471 | -0.552 |
| 5 | PARCO, A | 5 | * | -0.598 | -0.560 |
| 5 | PETRO-CA | | | | |
| | | 3 | —— | -0.535 | -0.556 |
| | | 8 | —— | 0.090 | 0.006 |
| | | | | | |
| | | 5 | * | -0.495 | -0.547 |
| 10 | PARCO, | 5 | 115 | -0.684 | -0.732 |
| 10 | PETRO-C | | | | |
| | | 5 | —— | -0.590 | -0.640 |
| | | — | —— | 0.134 | 0.131 |
| | | | | | |
| | | 7 | 117 | -0.576 | -0.597 |
| 15 | MARATHO | 6 | * | -0.650 | * |
| 15 | NOCO EN | 6 | * | -0.637 | -0.578 |
| 15 | PETRO-C | 9 | * | -0.479 | * |
| 15 | SHELL- C | 25 | 125 | -1.150 | -1.061 |
| 15 | UNITED | 24 | * | -0.943 | * |
| 15 | WARDEN | | | | |
| | | 20 | 121 | -0.739 | -0.745 |
| | | .0 | 5.7 | 0.254 | 0.274 |
| | | | | | |
| | | 20 | * | -0.605 | -0.571 |
| 20 | ATLANTI | 21 | * | -0.152 | -0.232 |
| 20 | CHEVRO | 19 | * | -0.187 | -0.244 |
| 20 | CIBRO | 22 | * | -0.672 | -0.616 |
| 20 | EXXON | 22 | * | -0.476 | -0.531 |
| 20 | MANTU | 22 | 120 | -0.602 | -0.624 |
| 20 | MARAT | 20 | * | -0.583 | -0.493 |
| 20 | PARCO | 20 | * | -0.444 | * |
| 20 | PECKHA | 25 | 122 | -0.871 | -0.765 |
| 20 | UNITE | 22 | * | -0.868 | * |
| 20 | WARDE | 22 | 112 | -0.452 | -0.371 |
| 20 | WEST | | | | |
| | | 21 | 118 | -0.537 | -0.494 |
| | | 1.6 | 5.3 | 0.233 | 0.180 |
| | | | | | |
| | | 18 | 112 | -0.668 | -0.574 |
| 85/100 | ESSO | 18 | 115 | -0.728 | -0.735 |
| 85/100 | PETRO | 18 | 119 | -0.750 | -0.827 |
| 85/100 | SHELL | 17 | 118 | -0.677 | -0.647 |
| 85/100 | ULTRA | | | | |
| | | 118 | 116 | -0.706 | -0.696 |
| | | .50 | 3.2 | 0.040 | 0.109 |

* RESULTS NOT GIVEN

| 1986 ASPHALT CEMENT MONITOR PROGRAM | | | DUCTILITY | COMPARATIVE | DUCTILITY | COMPARATIVE | SOLUBILITY | COMPARATIVE | SOFTENING | COMPARATIVE | PVN | COMPARATIVE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| AC | SUPPLIER-LOCATION- LOT | CRUDE SOURCE | @ 39.2°F | RESULTS | @ 77°F | RESULTS | % | RESULTS | POINT, °F | RESULTS | | RESULTS |
| FLUX | CHEVRON, PERTH AMBOY 18 | MAYAN BOSCAN | 150+ | * | 150+ | * | 99.98 | 99.93 | 114 | * | -0.097 | -0.145 |
| FLUX | CIBRO, ALBANY 35 | BOSCAN | 150+ | * | 150+ | 150+ | 99.99 | 99.98 | 111 | * | -0.148 | -0.194 |
| FLUX | MARATHON, TONAWANDA 16 | MID-CONTINENT CANADIAN | 150+ | 110+ | 150+ | 150+ | 99.98 | 99.98 | 109 | 113 | -0.538 | -0.514 |
| | $\bar{X}$ | | 150+ | 110+ | 150+ | 150+ | 99.98 | 99.96 | 111 | 113 | -0.261 | -0.284 |
| | $\sigma$ | | — | — | — | — | 0.01 | 0.03 | 2.5 | — | 0.241 | 0.200 |
| 5 | PARCO, ATHENS — | MENI-MOTA | 150+ | * | 150+ | 150+ | 99.99 | 99.99 | 110 | * | -0.471 | -0.552 |
| 5 | PETRO-CAN., OAKVILLE 220 | WESTERN CANADIAN | 150+ | 150+ | 150+ | — | 99.99 | 99.95 | 106 | * | -0.598 | -0.560 |
| | $\bar{X}$ | | 150+ | — | 150+ | — | 99.99 | 99.97 | 108 | — | -0.535 | -0.556 |
| | $\sigma$ | | — | — | — | — | — | 0.03 | 2.8 | — | 0.090 | 0.006 |
| 10 | PARCO, ATHENS 16 | MENI-MOTA | 150+ | * | 150+ | 150+ | 99.99 | 99.98 | 115 | * | -0.495 | -0.547 |
| 10 | PETRO-CAN., MONTREAL 12 | VENEZUELAN CANADIAN | 76.50 | 30+ | 150+ | 140+ | 99.99 | 99.91 | 115 | 115 | -0.684 | -0.732 |
| | $\bar{X}$ | | 113.3 | — | 150+ | — | 99.99 | 99.95 | 115 | — | -0.590 | -0.640 |
| | $\sigma$ | | 52.0 | — | — | — | — | 0.05 | — | — | 0.134 | 0.131 |
| 15 | MARATHON, TONAWANDA 14 | MID-CONTINENT CANADIAN | 83.50 | 110+ | 150+ | 150+ | 99.98 | 99.98 | 117 | 117 | -0.576 | -0.597 |
| 15 | NOCO ENERGY, TONAWANDA 6 | WESTERN CANADIAN | 28.50 | * | 150+ | * | 99.97 | * | 116 | * | -0.650 | * |
| 15 | PETRO-CAN., OAKVILLE 240 | WESTERN CANADIAN | 53.75 | 24.8 | 150+ | * | 99.99 | 99.96 | 116 | * | -0.637 | -0.578 |
| 15 | SHELL-CAN, HAMILTON 1 | VENEZUELAN | 63.75 | * | 150+ | * | 99.99 | * | 119 | * | -0.479 | * |
| 15 | UNITED REF., WARREN, PA. 8 | CANADIAN | 5.25 | * | 150+ | 120+ | 99.24 | 99.50 | 125 | 125 | -1.150 | -1.061 |
| 15 | WARDEN, PITTSFORD 34 | CANADIAN | 5.50 | * | 150+ | * | 99.31 | * | 124 | * | -0.943 | * |
| | $\bar{X}$ | | 40.0 | — | 150+ | — | 99.75 | 99.81 | 120 | 121 | -0.739 | -0.745 |
| | $\sigma$ | | 32.2 | — | — | — | 0.37 | 0.27 | 4.0 | 5.7 | 0.254 | 0.274 |
| 20 | ATLANTIC, PHILADELPHIA, PA. 60 | MEREY BACHAQUERO | 33.75 | * | 150+ | * | 99.99 | 99.94 | 120 | * | -0.605 | -0.571 |
| 20 | CHEVRON, PERTH AMBOY 19 | MAYAN BOSCAN | 21.50 | * | 150+ | * | 99.97 | 99.95 | 121 | * | -0.152 | -0.232 |
| 20 | CIBRO, ALBANY 36 | BOSCAN | 150+ | * | 150+ | 150+ | 99.96 | 99.96 | 119 | * | -0.187 | -0.244 |
| 20 | EXXON, LINDEN, N.J. 21 | NORTH SLOPE MAYA, MEX. | 11.25 | * | 150+ | 150+ | 99.99 | 99.99 | 122 | * | -0.672 | -0.616 |
| 20 | MANTUA, PAULSBORO, N.J. 28 | WESTERN VENEZUELAN | 150+ | * | 150+ | * | 99.99 | 99.97 | 122 | * | -0.476 | -0.531 |
| 20 | MARATHON, TONAWANDA 15 | MID-CONTINENT CANADIAN | 15.25 | 38 | 150+ | 150+ | 99.99 | 99.97 | 122 | 120 | -0.602 | -0.624 |
| 20 | PARCO, ATHENS 17 | MENI-MOTA TIJUANA PESADA | 93.0 | * | 150+ | 150+ | 99.98 | 99.98 | 120 | * | -0.583 | -0.493 |
| 20 | PECKHAM, STAMFORD, CT. 28 | VENEZUELAN | 45.25 | * | 150+ | * | 99.99 | * | 120 | * | -0.444 | * |
| 20 | UNITED REF., WARREN, PA. 14 | CANADIAN | 9.25 | * | 150+ | 120+ | 99.78 | 99.50 | 125 | 122 | -0.871 | -0.765 |
| 20 | WARDEN, PITTSFORD 27 | CANADIAN | 9.50 | * | 150+ | * | 99.76 | * | 122 | * | -0.868 | * |
| 20 | WEST BANK, PERTH AMBOY 8 | VENEZUELAN | 17.75 | 44 | 150+ | 100+ | 99.98 | 99.95 | 122 | 112 | -0.452 | -0.371 |
| | $\bar{X}$ | | 50.6 | 41 | 150+ | — | 99.94 | 99.91 | 121 | 118 | -0.537 | -0.494 |
| | $\sigma$ | | 54.8 | 4.2 | — | — | 0.09 | 0.16 | 1.6 | 5.3 | 0.233 | 0.180 |
| 85/100 | ESSO REF., MONTREAL 1 | VENEZUELAN CANADIAN | 17.50 | 11 | 150+ | 150+ | 99.98 | 99.97 | 118 | 112 | -0.668 | -0.574 |
| 85/100 | PETRO-CAN., MONTREAL 13 | VENEZUELAN CANADIAN | 57.25 | 30+ | 150+ | 140+ | 99.97 | 99.96 | 118 | 115 | -0.728 | -0.735 |
| 85/100 | SHELL-CAN., MONTREAL 9 | CANADIAN MEXICAN | 17.25 | 10 | 150+ | 150+ | 99.90 | 99.70 | 118 | 119 | -0.750 | -0.827 |
| 85/100 | ULTRAMAR, MONTREAL 3 | VENEZUELAN | 57.0 | 34 | 150+ | 150+ | 99.99 | 99.99 | 117 | 118 | -0.677 | -0.647 |
| | $\bar{X}$ | | 37.3 | — | 150+ | — | 99.96 | 99.91 | 118 | 116 | -0.706 | -0.696 |
| | $\sigma$ | | 23.0 | — | — | — | 0.04 | 0.14 | 0.50 | 3.2 | 0.040 | 0.109 |

* RESULTS NOT GIVEN

| 1986 ASP | LAR | | | | |
|---|---|---|---|---|---|
| MONITOR | MATICS | | | | |
| AC | SUPPLI | 0.22 | | | |
| FLUX | CHEVRO | 2.03 | | | |
| FLUX | CIBRO | .70 | | | |
| FLUX | MARAT | | | | |
| | | .32 | | | |
| | | 0.96 | | | |
| | | | | | |
| | | | | | |
| | | 5.91 | | | |
| 5 | PARCO | 3.62 | | | |
| 5 | PETRO | | | | |
| | | 7.27 | | | |
| | | .92 | | | |
| | | | | | |
| | | | | | |
| | | 7.76 | | | |
| 10 | PARCO | 7.35 | | | |
| 10 | PETRO | | | | |
| | | 7.56 | | | |
| | | 0.29 | | | |
| | | | | | |
| | | | | | |
| | | 2.87 | | | |
| 15 | MARA | 1.20 | | | |
| 15 | NOCO | 2.10 | | | |
| 15 | PETRO | 8.72 | | | |
| 15 | SHEL | 8.57 | | | |
| 15 | UNITE | 9.78 | | | |
| 15 | WARD | | | | |
| | | 0.54 | | | |
| | | 1.79 | | | |
| | | | | | |
| | | | | | |
| | | 4.09 | | | |
| 20 | ATLAN | 7.75 | | | |
| 20 | CHEV | 0.92 | | | |
| 20 | CIBA | 8.71 | | | |
| 20 | EXXO | 4.69 | | | |
| 20 | MAN | 5.42 | | | |
| 20 | MAR | 7.45 | | | |
| 20 | PAR | 7.05 | | | |
| 20 | PECK | 1.88 | | | |
| 20 | UNIT | 2.44 | | | |
| 20 | WAR | 9.25 | | | |
| 20 | WES | | | | |
| | | 39.97 | | | |
| | | 3.27 | | | |
| | | | | | |
| | | | | | |
| | | 7.73 | | | |
| 85/100 | ESSO | 7.70 | | | |
| 85/100 | PETRO | 7.16 | | | |
| 85/100 | SHEL | 9.20 | | | |
| 85/100 | ULTR | | | | |
| | | | | | |
| | | 37.95 | | | |
| | | 0.88 | | | |
| | | | | | |

* RESULTS NOT GIVEN

# 1986 ASPHALT CEMENT MONITOR PROGRAM

| AC | SUPPLIER - LOCATION - LOT | CRUDE SOURCE | PIN | COMPARATIVE RESULTS | SETTLEMENT TEST MINUTES | ASPHALTENES % | SATURATES % | % NAPHTHENE AROMATICS | % POLAR AROMATICS |
|---|---|---|---|---|---|---|---|---|---|
| FLUX | CHEVRON, PERTH AMBOY 18 | MAYAN BOSCAN | +1.380 | * | 27.3 | 17.11 | 9.70 | 25.33 | 40.22 |
| FLUX | CIBRO, ALBANY 35 | BOSCAN | −0.177 | * | 28.3 | 15.91 | 8.64 | 25.03 | 42.03 |
| FLUX | MARATHON, TONAWANDA 16 | MID-CONTINENT CANADIAN | +0.089 | +1.107 | 56.3 | 10.90 | 10.29 | 29.30 | 41.70 |
| | $\bar{X}$ | | 0.431 | —— | 37.3 | 14.64 | 9.54 | 26.55 | 41.32 |
| | $\sigma$ | | 0.833 | —— | 16.5 | 3.29 | 0.84 | 2.38 | 0.96 |
| 5 | PARCO, ATHENS —— | MENI-MOTA | +0.454 | * | 74.8 | 13.63 | 13.44 | 29.56 | 35.91 |
| 5 | PETRO-CAN., OAKVILLE 220 | WESTERN CANADIAN | −0.559 | * | 30.9 | 10.84 | 11.98 | 32.01 | 38.62 |
| | $\bar{X}$ | | −0.053 | —— | 52.9 | 12.24 | 12.71 | 30.79 | 37.27 |
| | $\sigma$ | | 0.716 | —— | 31.0 | 1.97 | 1.03 | 1.73 | 1.92 |
| 10 | PARCO, ATHENS 16 | MENI-MOTA | +0.016 | * | 79.0 | 11.31 | 18.15 | 23.91 | 37.76 |
| 10 | PETRO-CAN., MONTREAL 12 | VENEZUELAN CANADIAN | −0.600 | −0.665 | 43.8 | 14.09 | 12.26 | 31.94 | 37.35 |
| | $\bar{X}$ | | −0.292 | —— | 61.4 | 12.70 | 15.21 | 27.93 | 37.56 |
| | $\sigma$ | | 0.436 | —— | 24.9 | 1.97 | 4.16 | 5.68 | 0.29 |
| 15 | MARATHON, TONAWANDA 14 | MID-CONTINENT CANADIAN | −0.397 | −0.430 | 42.6 | 12.39 | 8.92 | 28.61 | 42.87 |
| 15 | NOCO ENERGY, TONAWANDA 6 | WESTERN CANADIAN | −0.828 | * | 29.7 | 12.00 | 8.75 | 28.69 | 41.20 |
| 15 | PETRO-CAN., OAKVILLE 240 | WESTERN CANADIAN | −0.761 | * | 31.3 | 12.25 | 9.26 | 28.93 | 42.10 |
| 15 | SHELL-CAN., HAMILTON 1 | VENEZUELAN | −0.246 | * | 105.9 | 12.09 | 11.08 | 32.68 | 38.72 |
| 15 | UNITED REF., WARREN, PA. 8 | CANADIAN | −0.479 | −0.227 | 54.7 | 12.18 | 10.15 | 33.82 | 38.57 |
| 15 | WARDEN, PITTSFORD 34 | CANADIAN | −0.324 | * | 66.4 | 9.03 | 8.40 | 34.15 | 39.78 |
| | $\bar{X}$ | | −0.506 | −0.329 | 55.1 | 11.66 | 9.43 | 31.15 | 40.54 |
| | $\sigma$ | | 0.238 | 0.144 | 28.6 | 1.29 | 1.01 | 2.68 | 1.79 |
| 20 | ATLANTIC, PHILADELPHIA, PA. 60 | MEREY BACHAQUERO | −0.372 | * | 72.6 | 8.36 | 11.00 | 28.97 | 44.09 |
| 20 | CHEVRON, PERTH AMBOY 19 | MAYAN BOSCAN | +0.167 | * | 18.6 | 19.50 | 16.12 | 18.88 | 37.75 |
| 20 | CIBRO, ALBANY 36 | BOSCAN | +0.024 | * | 28.3 | 16.78 | 18.43 | 15.02 | 40.92 |
| 20 | EXXON, LINDEN, N.J. 21 | NORTH SLOPE MAYA, MEX. | −0.449 | * | 39.5 | 15.14 | 9.37 | 31.68 | 38.71 |
| 20 | MANTUA, PAULSBORO, N.J. 28 | WESTERN VENEZUELAN | −0.073 | * | 114.5 | 13.52 | 10.71 | 32.05 | 34.69 |
| 20 | MARATHON, TONAWANDA 15 | MID-CONTINENT CANADIAN | −0.372 | −0.592 | 41.8 | 12.59 | 7.64 | 27.37 | 45.42 |
| 20 | PARCO, ATHENS 17 | MENI-MOTA TIJUANA PESADA | −0.408 | * | 67.3 | 14.43 | 10.15 | 27.98 | 37.45 |
| 20 | PECKHAM, STAMFORD, CT. 28 | VENEZUELAN | −0.408 | * | 71.4 | 14.78 | 11.31 | 28.69 | 37.05 |
| 20 | UNITED REF., WARREN, PA. 14 | CANADIAN | −0.394 | −0.567 | 24.4 | 13.87 | 10.30 | 26.43 | 41.88 |
| 20 | WARDEN, PITTSFORD 27 | CANADIAN | −0.810 | * | 24.9 | 12.69 | 9.22 | 27.07 | 42.44 |
| 20 | WEST BANK, PERTH AMBOY 8 | VENEZUELAN | −0.183 | −1.567 | 91.7 | 13.22 | 10.41 | 28.48 | 39.25 |
| | $\bar{X}$ | | −0.298 | −0.909 | 54.1 | 14.08 | 11.33 | 26.60 | 39.97 |
| | $\sigma$ | | 0.267 | 0.570 | 31.5 | 2.76 | 3.15 | 5.15 | 3.27 |
| 85/100 | ESSO REF., MONTREAL 1 | VENEZUELAN CANADIAN | −0.752 | −1.502 | 84.4 | 14.97 | 9.33 | 29.24 | 37.73 |
| 85/100 | PETRO-CAN., MONTREAL 13 | VENEZUELAN CANADIAN | −0.404 | −0.794 | 40.4 | 14.58 | 11.43 | 28.69 | 37.70 |
| 85/100 | SHELL-CAN., MONTREAL 9 | CANADIAN MEXICAN | −0.438 | −0.280 | 22.0 | 14.77 | 11.71 | 27.30 | 37.16 |
| 85/100 | ULTRAMAR, MONTREAL 3 | VENEZUELAN | −0.598 | −0.269 | 67.9 | 12.58 | 21.19 | 17.31 | 39.20 |
| | $\bar{X}$ | | −0.548 | −0.711 | 53.7 | 14.23 | 13.42 | 25.64 | 37.95 |
| | $\sigma$ | | 0.160 | 0.581 | 27.8 | 1.11 | 5.29 | 5.61 | 0.88 |

* RESULTS NOT GIVEN

Three suppliers submitted Asphalt Composition Analysis Results to the Materials Bureau.

A. Petro-Canada, Montreal, Quebec
#702-0300, AC-10 Lot 12 Venezuelan Canadian

Asphalt Composition Analysis

| | Materials Bureau | Petro Canada |
|---|---|---|
| % Asphaltenes, | 14.09 | 16.5 |
| % Saturates, | 12.26 | 19.1 |
| % Naphthene Aromatics, | 31.94 | 37.7 |
| % Polar Aromatics, | 37.35 | 26.7 |

Petro-Canada, Montreal, Que
#702-0600, 85/100 Lot 13 Venezuelan Canadian

Asphalt Composition Analysis

| | Materials Bureau | Petro Canada |
|---|---|---|
| % Asphaltenes | 14.58 | 16.9 |
| % Saturates | 11.43 | 20.1 |
| % Naphthene Aromatics | 28.69 | 35.4 |
| % Polar Aromatics | 37.70 | 27.6 |

B. Shell Canada, Montreal, Que.
#702-0600, 85/100 Lot 9 Canadian, Mexican

Asphalt Composition Analysis

| | Materials Bureau | Shell-Canada |
|---|---|---|
| %Asphaltenes | 14.77 | 14.1 |
| % Saturates | 11.71 | 15.5 |
| % Aromatics | - | 50.9 |
| % Resins | - | 19.5 |

C. Ultramar, Montreal, Que.
#702-0600, 85/100 Lot 3 Venezuelan

| | Materials Bureau | Ultramar |
|---|---|---|
| % Asphaltenes | 12.58 | 29.02 |

## VIII. Statistical Analysis of Test Results

The mean, range and standard deviation were determined for the number of samples tested in each grade of asphalt cement. For each test, this statistical information has been determined separately for the Materials Bureau results and when applicable, the comparable results submitted by the supplier.

### A. ABSOLUTE VISCOSITY @ 140°F (POISES)

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 840 | 593 | 1157 | 1525 | 1972 | 1361 |
| Range | 607 to 1138 | 561 to 624 | 1139 to 1175 | 1425 to 1753 | 1746 to 2145 | 1195 to 1560 |
| Standard Deviation | 271.5 | 44.5 | 25.5 | 124.1 | 157.2 | 160.5 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 5 | 11 | 4 |
| Mean | 823 | 616 | 1158 | 1475 | 1900 | 1339 |
| Range | 632 to 1101 | 574 to 658 | - | 1405 to 1546 | 1652 to 2114 | 1161 to 1492 |
| Standard Deviation | 246.5 | 59.4 | - | 54.6 | 158.4 | 141.9 |

### B. KINEMATIC VISCOSITY @ 275°F (CENTISTOKES)

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 284 | 230 | 305 | 344 | 404 | 334 |
| Range | 232 to 334 | 224 to 235 | 302 to 307 | 316 to 378 | 373 to 458 | 318 to 364 |
| Standard Deviation | 51.0 | 7.8 | 3.5 | 19.9 | 26.9 | 21.2 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 3 | 9 | 4 |
| Mean | 275 | 227 | 302 | 335 | 401 | 326 |
| Range | 227 to 321 | 225 to 228 | - | 315 to 351 | 368 to 442 | 302 to 364 |
| Standard Deviation | 47.1 | 2.1 | - | 18.2 | 23.3 | 27.4 |

C. PENETRATION @ 77°F

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 154 | 162 | 105 | 78 | 75 | 83 |
| Range | 134 to 170 | 159 to 165 | 95 to 115 | 57 to 91 | 59 to 94 | 76 to 86 |
| Standard Deviation | 18.4 | 4.2 | 14.1 | 13.7 | 10.8 | 4.7 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 158 | 162 | 102 | 75 | 77 | 87 |
| Range | 136 to 170 | 161 to 163 | 93 to 110 | 63 to 90 | 65 to 95 | 83 to 90 |
| Standard Deviation | 18.8 | 1.4 | 12.0 | 12.4 | 9.4 | 3.3 |

D. PENETRATION @ 39.2°F

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 56 | 49 | 35 | 25 | 28 | 29 |
| Range | 49 to 65 | 45 to 53 | 32 to 38 | 18 to 30 | 21 to 34 | 26 to 30 |
| Standard Deviation | 8.3 | 5.7 | 4.2 | 5.2 | 4.6 | 1.7 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 2 | - | 1 | 2 | 5 | 4 |
| Mean | 48 | - | - | 23 | 27 | 35 |
| Range | 47to 49 | - | - | 16 to 29 | 17 to 34 | 30 to 43 |
| Standard Deviation | 1.4 | - | - | 9.2 | 7.4 | 5.6 |

## E. PENETRATION RATIO

(PENETRATION @ 39.2°F divided by PENETRATION @ 77°F) X 100

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 36.2 | 30.2 | 33.4 | 31.4 | 37.0 | 34.3 |
| Range | 30.8 to 39.6 | 28.3 to 32.1 | 33.0 to 33.7 | 28.1 to 34.9 | 30.9 to 42.7 | 33.7 to 35.3 |
| Standard Deviation | 4.7 | 2.7 | 0.5 | 2.3 | 3.1 | 0.7 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 2 | 0 | 1 | 2 | 5 | 4 |
| Mean | 32.0 | - | - | 28.8 | 33.4 | 40.3 |
| Range | 29.3 to 34.6 | - | - | 25.4 to 32.2 | 26.2 to 39.0 | 35.3 to 48.3 |
| Standard Deviation | 3.7 | - | - | 4.8 | 5.5 | 5.8 |

-

## F. THIN FILM OVEN TEST, % LOSS

(SAMPLES WHICH SHOWED WEIGHT GAINS WERE CALCULATED AS 0.000% LOSS)

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 26 | 6 | 11 | 4 |
| Mean | 0.525 | 0.117 | 0.099 | 0.147 | 0.159 | 0.033 |
| Range | 0.131 to 0.757 | 0.000 to 0.234 | 0.030 to 0.168 | 0.000 to 0.364 | 0.018 to 0.551 | 0.000 to 0.073 |
| Standard Deviation | 0.343 | 0.165 | 0.098 | 0.144 | 0.157 | 0.030 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 2 | 2 | 2 | 3 | 8 | 4 |
| Mean | 0.445 | 0.095 | 0.100 | 0.037 | 0.155 | 0.035 |
| Range | 0.160 to 0.730 | 0.000 to 0.190 | 0.070 to 0.130 | 0.000 to 0.110 | 0.000 to 0.610 | 0.000 to 0.070 |
| Standard Deviation | 0.403 | 0.134 | 0.042 | 0.064 | 0.194 | 0.029 |

G. THIN FILM OVEN TEST, DUCTILITY @ 60°F, 5cm/min. (CENTIMETERS)

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 133 | 150+ | 130 | 86.4 | 74.7 | 71.4 |
| Range | 99 to 150+ | - | 109 to 150+ | 14.25 to 150+ | 24.25 to 150+ | 47.25 to 98.75 |
| Standard Deviation | 29.4 | - | 29.0 | 61.5 | 47.4 | 21.8 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 2 | 0 | 1 | 2 | 6 | 4 |
| Mean | 150+ | - | - | 84.5 | 81.7 | 100.0 |
| Range | - | - | - | 19 to 150+ | 23.0 to 150+ | 35 to 150+ |
| Standard Deviation | - | - | - | 92.6 | 54.2 | 48.8 |

H. THIN FILM OVEN TEST, DUCTILITY @ 77°F, 5cm/min. (CENTIMETERS)

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 150+ | 150+ | 150+ | 150.0+ | 150+ | 150+ |
| Range | - | - | - | - | - | - |
| Standard Deviation | - | - | - | - | - | - |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 3 | 8 | 4 |
| Mean | - | 150+ | - | - | - | - |
| Range | 110+ to 150+ | - | 140+ to 150+ | 120+ to 150+ | 100+ to 150+ | 80 to 150+ |
| Standard Deviation | - | - | - | - | - | - |

## I. THIN FILM OVEN TEST, ABSOLUTE VISCOSITY @ 140°F, (POISES)

### 1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 2281 | 1331 | 2844 | 3693 | 5130 | 3539 |
| Range | 1283 to 3096 | 1088 to 1573 | 2721 tp 2966 | 2875 to 4514 | 4102 to 6603 | 3228 to 3910 |
| Standard Deviation | 920.2 | 342.9 | 173.2 | 607.6 | 845.5 | 290.9 |

### 2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 3 | 9 | 3 |
| Mean | 2243 | 1322 | 2661 | 3318 | 4748 | 3044 |
| Range | 1263 to 3035 | 1202 to 1442 | 2636 to 2685 | 3055 to 3620 | 3683 to 6014 | 2557 to 3578 |
| Standard Deviation | 900.8 | 169.7 | 34.6 | 284.6 | 781.7 | 512.1 |

## J. ABSOLUTE VISCOSITY @140°F RATIO

(AFTER T.F.O.T. VISCOSITY @ 140°F DIVIDED BY ORIGINAL VISCOSITY @ 140°F)

### 1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 2.67 | 2.23 | 2.46 | 2.41 | 2.59 | 2.61 |
| Range | 2.11 to 3.18 | 1.94 to 2.52 | 2.39 to 2.52 | 1.98 to 2.75 | 2.34 to 3.08 | 2.51 to 2.70 |
| Standard Deviation | 0.54 | 0.41 | 0.09 | 0.26 | 0.28 | 0.09 |

### 2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 3 | 9 | 3 |
| Mean | 2.69 | 2.14 | 2.30 | 2.30 | 2.50 | 2.39 |
| Range | 2.00 to 3.31 | 2.09 to 2.19 | 2.28 to 2.32 | 2.17 to 2.46 | 2.04 to 3.06 | 1.83 to 2.75 |
| Standard Deviation | 0.66 | 0.07 | 0.03 | 0.15 | 0.38 | 0.49 |

## K. THIN FILM OVEN TEST, KINEMATIC VISCOSITY @ 275°F, (CENTISTOKES)

### 1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 444 | 316 | 445 | 491 | 602 | 492 |
| Range | 316 to 536 | 296 to 336 | 441 to 449 | 448 to 564 | 531 to 748 | 470 to 528 |
| Standard Deviation | 114.2 | 28.3 | 5.7 | 40.3 | 71.0 | 25.2 |

### 2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 2 | 1 | 2 | 2 | 7 | 3 |
| Mean | 413 | - | 444 | 445 | 563 | 466 |
| Range | 298 to 528 | - | 432 to 455 | 430 to 460 | 483 to 662 | 444 to 506 |
| Standard Deviation | 162.6 | - | 16.3 | 21.2 | 59.5 | 34.7 |

## L. THIN FILM OVEN TEST, PENETRATION @ 77°F

### 1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 87 | 94 | 63 | 48 | 48 | 54 |
| Range | 77 to 96 | 91 to 96 | 58 to 68 | 37 to 55 | 42 to 56 | 51 to 56 |
| Standard Deviation | 9.5 | 3.5 | 7.1 | 8.4 | 4.7 | 2.2 |

### 2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 2 | 2 | 2 | 3 | 8 | 4 |
| Mean | 85 | 95 | 63 | 48 | 48 | 55 |
| Range | 75 to 95 | 93 to 96 | 60 to 66 | 36 to 55 | 38 to 54 | 50 to 62 |
| Standard Deviation | 14.1 | 2.1 | 4.2 | 10.7 | 5.3 | 5.4 |

M. PENETRATION @ 77°F RATIO,

(AFTER T.F.O.T. PENETRATION @77°F DIVIDED BY ORIGINAL PENETRATION @ 77°F) X 100

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 56.6 | 57.8 | 60.1 | 61.4 | 65.1 | 65.1 |
| Range | 51.8 to 60.4 | 55.2 to 60.4 | 59.1 to 61.1 | 57.8 to 64.9 | 59.6 to 74.6 | 63.5 to 67.1 |
| Standard Deviation | 4.4 | 3.7 | 1.4 | 2.9 | 4.6 | 1.7 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 2 | 2 | 2 | 3 | 4 | 4 |
| Mean | 56.0 | 58.4 | 62.3 | 60.1 | 61.3 | 63.7 |
| Range | 55.1 to 56.9 | 57.8 to 58.9 | 60.0 to 64.5 | 57.1 to 62.1 | 56.8 to 62.2 | 58.4 to 68.9 |
| Standard Deviation | 1.3 | 0.8 | 3.2 | 2.6 | 3.0 | 5.1 |

N. SPECIFIC GRAVITY @ 77°F

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 1.025 | 1.018 | 1.022 | 1.021 | 1.025 | 1.020 |
| Range | 1.020 to 1.027 | 1.017 to 1.018 | 1.021 to 1.022 | 1.012 to 1.026 | 1.018 to 1.032 | 1.017 to 1.023 |
| Standard Deviation | 0.004 | 0.001 | 0.001 | 0.005 | 0.004 | 0.003 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 3 | 9 | 4 |
| Mean | 1.024 | 1.019 | 1.022 | 1.023 | 1.026 | 1.020 |
| Range | 1.022 to 1.027 | 1.018 to 1.019 | 1.021 to 1.022 | 1.022 to 1.024 | 1.016 to 1.031 | 1.018 to 1.022 |
| Standard Deviation | 0.003 | 0.001 | 0.001 | 0.001 | 0.005 | 0.002 |

O. FLASH POINT, CLEVLAND OPEN CUP, °F

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 532 | 548 | 533 | 583 | 557 | 588 |
| Range | 495 to 565 | 530 to 565 | 525 to 540 | 545 to 620 | 485 to 635 | 560 to 610 |
| Standard Deviation | 35.1 | 24.7 | 10.6 | 31.6 | 46.9 | 21.0 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 3 | 9 | 4 |
| Mean | 517 | 567 | 563 | 606 | - | 605 |
| 605 Range | 475 to 580 | 525 to 608 | 540 to 585 | 580 to 622 | 485 to 600+ | 590 to 618 |
| Standard Deviation | 55.8 | 58.7 | 31.83 | 22.5 | - | 11.6 |

P. DUCTILITY @ 39.2°F, 1cm/min., ORIGINAL SAMPLE (CENTIMETERS)

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 150.0+ | 150+ | 113.3 | 40.0 | 50.6 | 37.3 |
| Range | - | - | 76.5 to 150+ | 5.25 to 83.50 | 9.25 to 150+ | 17.25 to 57.25 |
| Standard Deviation | - | - | 52.0 | 32.2 | 54.8 | 23.0 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 1 | 1 | 1 | 2 | 2 | 4 |
| Mean | - | - | - | - | 41 | - |
| Range | - | - | - | 24.8 to 110+ | 38 to 44 | 10 to 30+ |
| Standard Deviation | - | - | - | - | 4.2- | - |

## Q. DUCTILITY @ 77°F, 5cm/min., ORIGINAL SAMPLE (CENTIMETERS)

### 1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 150.0+ | 150+ | 150+ | 150.0+ | 150.0+ | 150.0+ |
| Range | - | - | - | - | - | - |
| Standard Deviation | - | - | - | - | - | - |

### 2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 2 | 1 | 2 | 2 | 6 | 4 |
| Mean | 150+ | - | - | - | - | - |
| Range | - | - | 140+ to 150+ | 120+ to 150+ | 100+ to 150+ | 140+ to 150+ |
| Standard Deviation | - | - | - | - | - | - |

## R. SOLUBILITY IN TRICHLOROETHYLENE, (%)

### 1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 99.98 | 99.99 | 99.99 | 99.75 | 99.94 | 99.96 |
| Range | 99.98 to 99.99 | - | - | 99.24 to 99.99 | 99.76 to 99.99 | 99.90 to 99.99 |
| Standard Deviation | 0.01 | - | - | 0.37 | 0.09 | 0.04 |

### 2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 3 | 9 | 4 |
| Mean | 99.96 | 99.97 | 99.95 | 99.81 | 99.91 | 99.91 |
| Range | 99.93 to 99.98 | 99.95 to 99.99 | 99.91 to 99.98 | 99.50 to 99.98 | 99.50 to 99.99 | 99.70 to 99.99 |
| Standard Deviation | 0.03 | 0.03 | 0.05 | 0.27 | 0.16 | 0.14 |

## S. SOFTENING POINT, IN ETHYLENE GLYCOL, (°F)

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 111 | 108 | 115 | 120 | 121 | 118 |
| Range | 109 to 114 | 106 to 110 | - | 116 to 125 | 119 to 125 | 117 to 118 |
| Standard Deviation | 2.5 | 2.8 | - | 4.0 | 1.6 | 0.50 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 1 | - | 1 | 6 | 3 | 4 |
| Mean | - | - | - | 121 | 118 | 116 |
| Range | - | - | - | 117 to 125 | 112 to 122 | 112 to 119 |
| Standard Deviation | - | - | - | 5.7 | 5.3 | 3.2 |

## T. Penetration Viscosity Number, (PVN)

The penetration viscosity number, PVN, is an indicator of the temperature susceptibility of asphalt cements. Lower PVN indicates greater temperature susceptibility. It is suggested that an asphalt cement with a PVN less than -0.5 is temperature susceptible.

$$PVN = \frac{\text{Log A} - \text{Log V}}{\text{Log A} - \text{Log B}} \times (-1.5)$$

Where Log A = 4.25800 - 0.79674 Log (Penetration @ 77°F)
Log B = 3.46289 - 0.61094 Log (Penetration @ 77°F)
Log V = Log (Viscosity @ 275°F, Kinematic)

The results indicate that most of these asphalt cements are temperature susceptible by PVN criteria.

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | -0.261 | -0.535 | -0.590 | -0.739 | -0.537 | -0.706 |
| Range | -0.097 to -0.538 | -0.471 to -0.598 | -0.495 to -0.684 | -0.479 to -1.150 | -0.152 to -0.871 | -0.668 to -0.750 |
| Standard Deviation | 0.241 | 0.090 | 0.134 | 0.254 | 0.233 | 0.040 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 3 | 9 | 4 |
| Mean | -0.284 | -0.556 | -0.640 | -0.745 | -0.494 | -0.696 |
| Range | -0.145 to -0.514 | -0.552 to -0.560 | -0.547 to -0.732 | -0.578 to -1.061 | -0.232 to -0.765 | -0.574 to -0.827 |
| Standard Deviation | 0.200 | 0.006 | 0.131 | 0.274 | 0.180 | 0.109 |

## U. Penetration Index Numbers, (PIN)

The penetration Index Number is another indicator of temperature susceptibility of asphalt cements. Large negative values of PIN indicate greater temperature susceptibility. "Typical" asphalts have values between +2 and -2.

$$PIN = \frac{30}{1 + 90\ PTS} - 10$$

PTS = Penetration Temperature Susceptibility

$$PTS = \frac{\text{Log } 800 - \text{Log (Penetration @ } 77°F)}{\text{Softening Point } (°F) - 77°F}$$

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 0.431 | -0.053 | -0.292 | -0.506 | -0.298 | -0.548 |
| Range | +1.380 to -0.177 | +0.454 to -0.559 | +0.016 to -0.600 | -0.246 to -0.828 | +0.167 to -0.810 | -0.404 to -0.[illegible] |
| Standard Deviation | 0.833 | 0.716 | 0.436 | 0.238 | 0.267 | 0.160 |

2. Comparative Results

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 1 | 0 | 1 | 2 | 3 | 4 |
| Mean | - | - | - | -0.329 | -0.909 | -0.711 |
| Range | - | - | - | -0.227 to -0.430 | -0.567 to -1.567 | -0.269 to -1.[illegible] |
| Standard Deviation | - | - | - | 0.144 | 0.570 | 0.581 |

## V. A Settling Test to Evaluate The Relative Degree of Dispersion of Asphaltenes

by

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The asphaltene settling test is used to evaluate the relative degree of dispersion of asphaltenes from paving asphalts. This test distinguishes differences in asphaltene settling times of asphalts in their hexane-maltene solutions. The test involves digesting asphalt in n-hexane, transferring the contents into a graduated cylinder and measuring the time required for the asphaltene meniscus to settle to the 25 ml. mark of a 50 ml. cylinder. Slower settling times indicate a greater degree of dispersion of the asphaltenes and thus a more compatible asphalt, which in turn is considered to be an important property that contributes to asphalt durability. The test is extremely sensitive to changes in asphalt composition. Time is reported in minutes.

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 37.3 | 52.9 | 61.4 | 55.1 | 54.1 | 53.7 |
| Range | 27.3 to 56.3 | 30.9 to 74.8 | 43.8 to 79.0 | 29.7 to 105.9 | 18.6 to 114.5 | 22.0 to 84.4 |
| Standard Deviation | 16.5 | 31.0 | 24.9 | 28.6 | 31.5 | 27.8 |

## W. Separation of Asphalt Into Four Fractions; Modified Method of ASTM D 4124-84, Section 4, Volume 04.03

The purpose is to separate the four generic fractions present in asphalt. These fractions are saturates, naphthene aromatics, polar aromatics, and asphaltenes. The relative amount of each fraction plays a role in determining the physical properties of the asphalt. These properties include viscosity, ductility, softening point and temperature susceptibility.

The procedure follows:

The percent asphaltene is determined by dispersing the asphalt in n-heptane and refluxing. The insolubles are the asphaltenes.

The remaining three fractions are determined by absorbing the deasphaltened n-heptane solution on a calcined alumina chromatography column and eluting (removing) each fraction with a different solvent. Saturates are eluted with n-heptane. Naphthene aromatics are eluted with toluene. Polar Aromatics are eluted with 50/50 toluene - methanol solution, followed by trichloroethylene. The solvents are then evaporated and weight percentages of each fraction with respect to the original asphalt sample are determined.

### ASPHALTENES, %

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 14.64 | 12.24 | 12.70 | 11.66 | 14.08 | 14.23 |
| Range | 10.90 to 17.11 | 10.84 to 13.63 | 11.31 to 14.09 | 9.03 to 12.39 | 8.36 to 19.50 | 12.58 to 14 |
| Standard Deviation | 3.29 | 1.97 | 1.97 | 1.29 | 2.76 | 1.11 |

### SATURATES, %

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 9.54 | 12.71 | 15.21 | 9.43 | 11.33 | 13.42 |
| Range | 8.64 to 10.29 | 11.98 to 13.44 | 12.26 to 18.15 | 8.40 to 11.08 | 7.64 to 18.43 | 9.33 to 21.19 |
| Standard Deviation | 0.84 | 1.03 | 4.16 | 1.01 | 3.15 | 5.29 |

## NAPHTHENE - AROMATICS, %

1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 26.55 | 30.79 | 27.93 | 31.15 | 26.60 | 25.64 |
| Range | 25.03 to 29.30 | 29.56 to 32.01 | 23.91 to 31.94 | 28.61 to 34.15 | 15.02 to 32.05 | 17.31 to 29.24 |
| Standard Deviation | 2.38 | 1.73 | 5.68 | 2.68 | 5.15 | 5.61 |

## POLAR AROMATICS, %

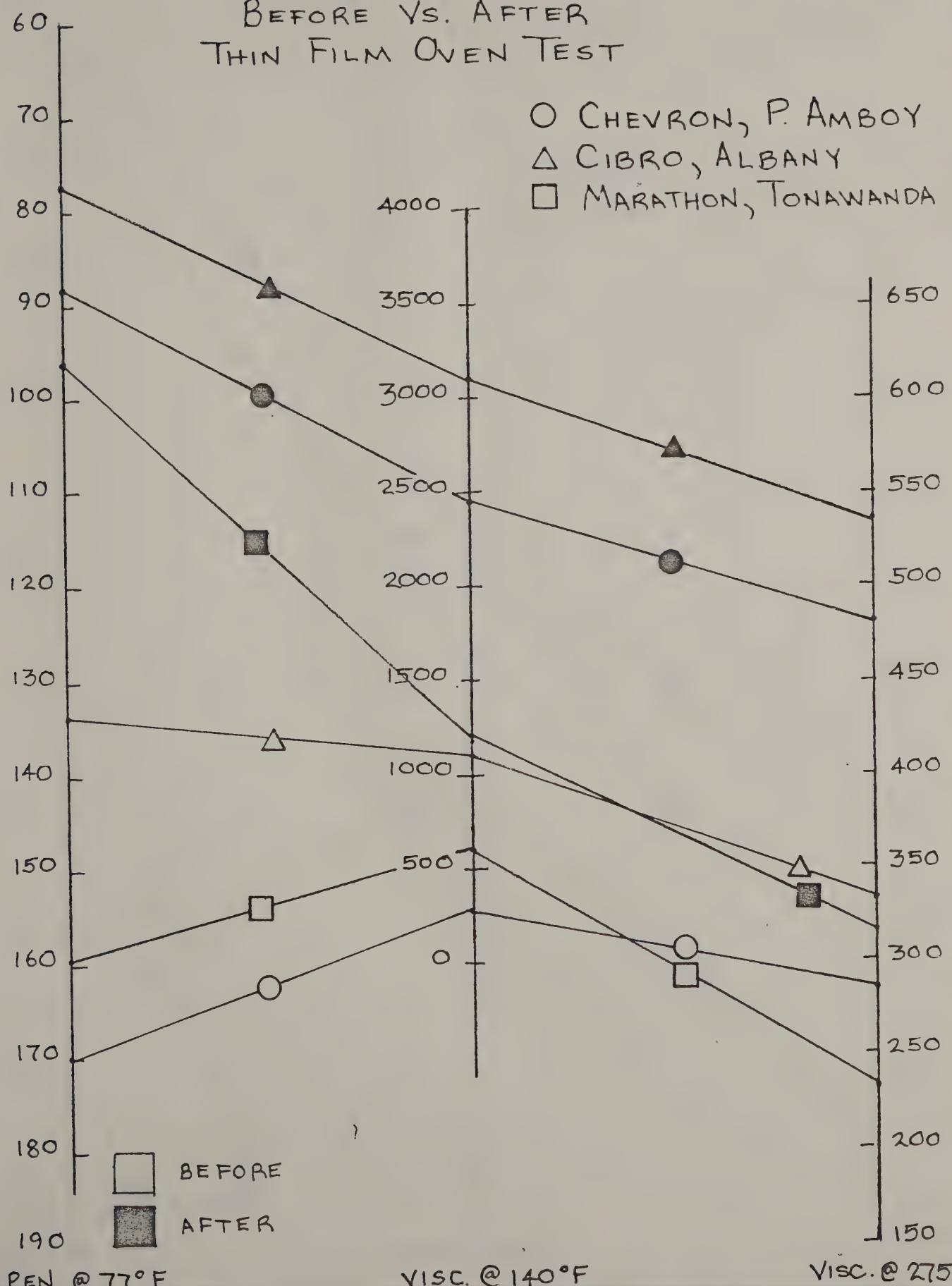
1. Materials Bureau

| | FLUX | AC-5 | AC-10 | AC-15 | AC-20 | 85/100 |
|---|---|---|---|---|---|---|
| Number of Samples | 3 | 2 | 2 | 6 | 11 | 4 |
| Mean | 41.32 | 37.27 | 37.56 | 40.54 | 39.97 | 37.95 |
| Range | 41.70 to 42.03 | 35.91 to 38.62 | 37.35 to 37.76 | 38.57 to 42.87 | 34.69 to 45.42 | 37.16 to 39.20 |
| Standard Deviation | 0.96 | 1.92 | 0.29 | 1.79 | 3.27 | 0.88 |

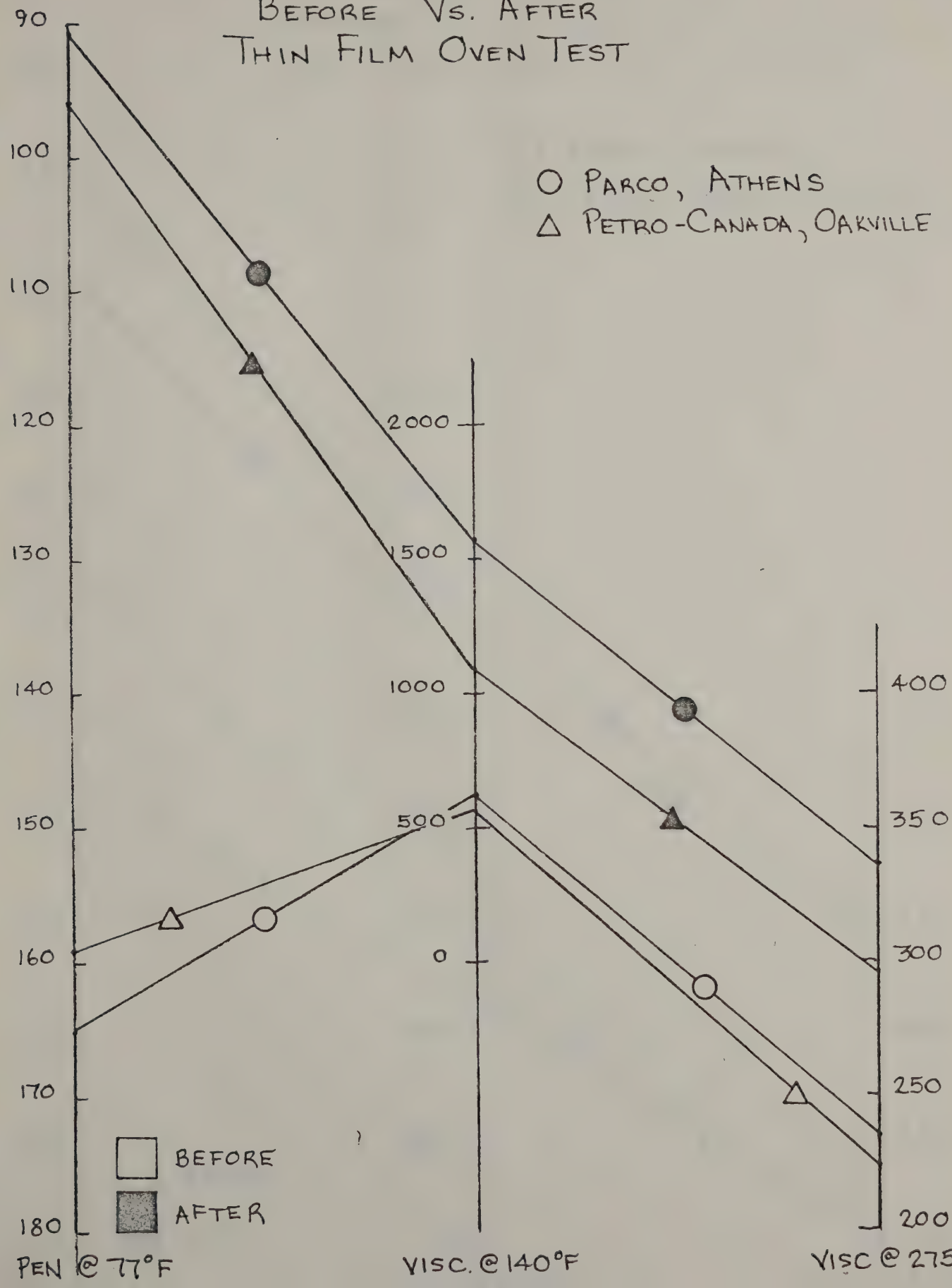
## IX. GRAPHS AND CHARTS OF RELATED MATERIAL INFORMATION

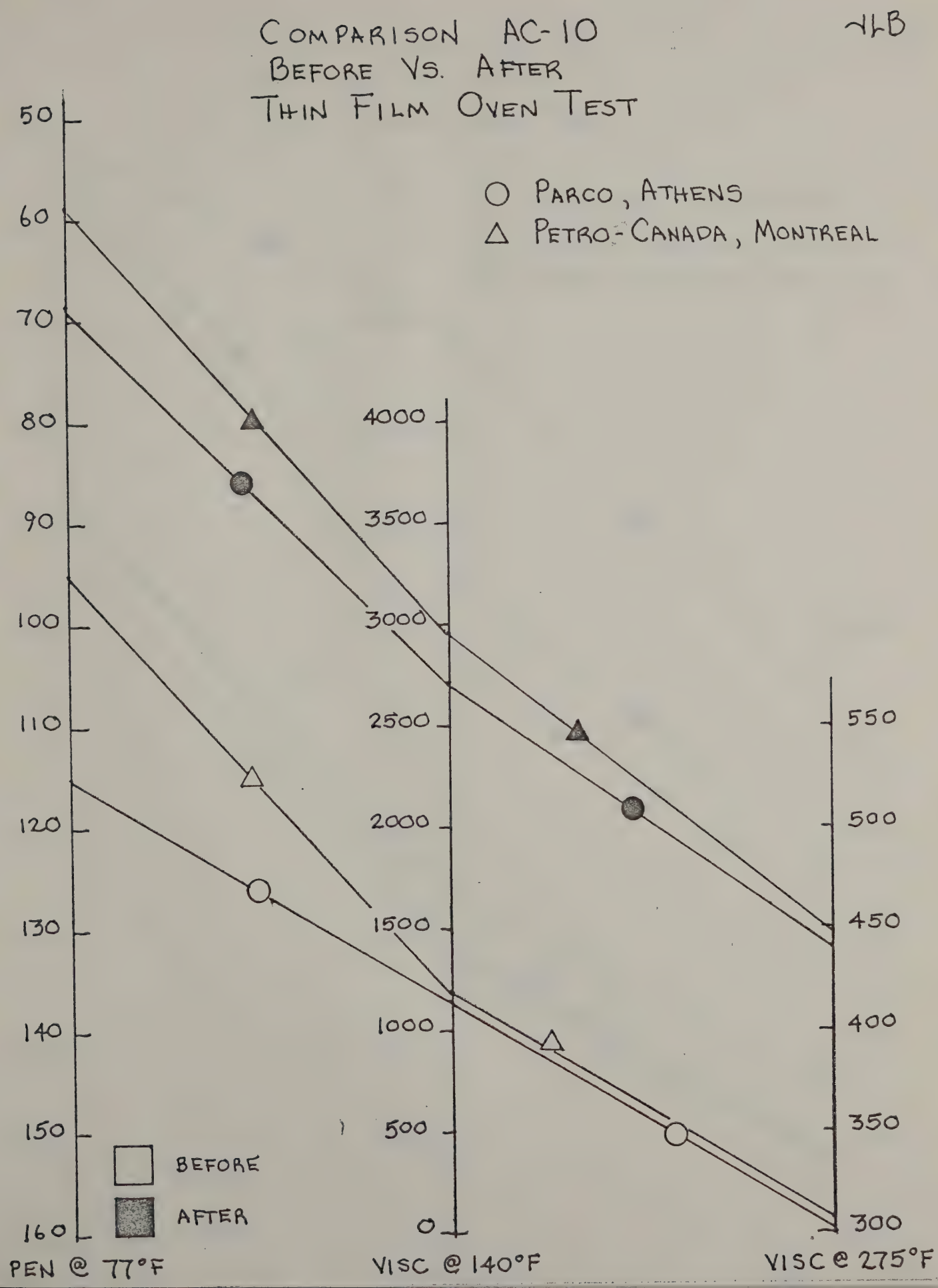
On the following pages are found a series of graphs providing a comparison of thin film oven test, before and after, and charts showing asphaltene dispersion settling test.

# Comparison Flux, Before Vs. After Thin Film Oven Test



# Comparison AC-5
## Before Vs. After
## Thin Film Oven Test

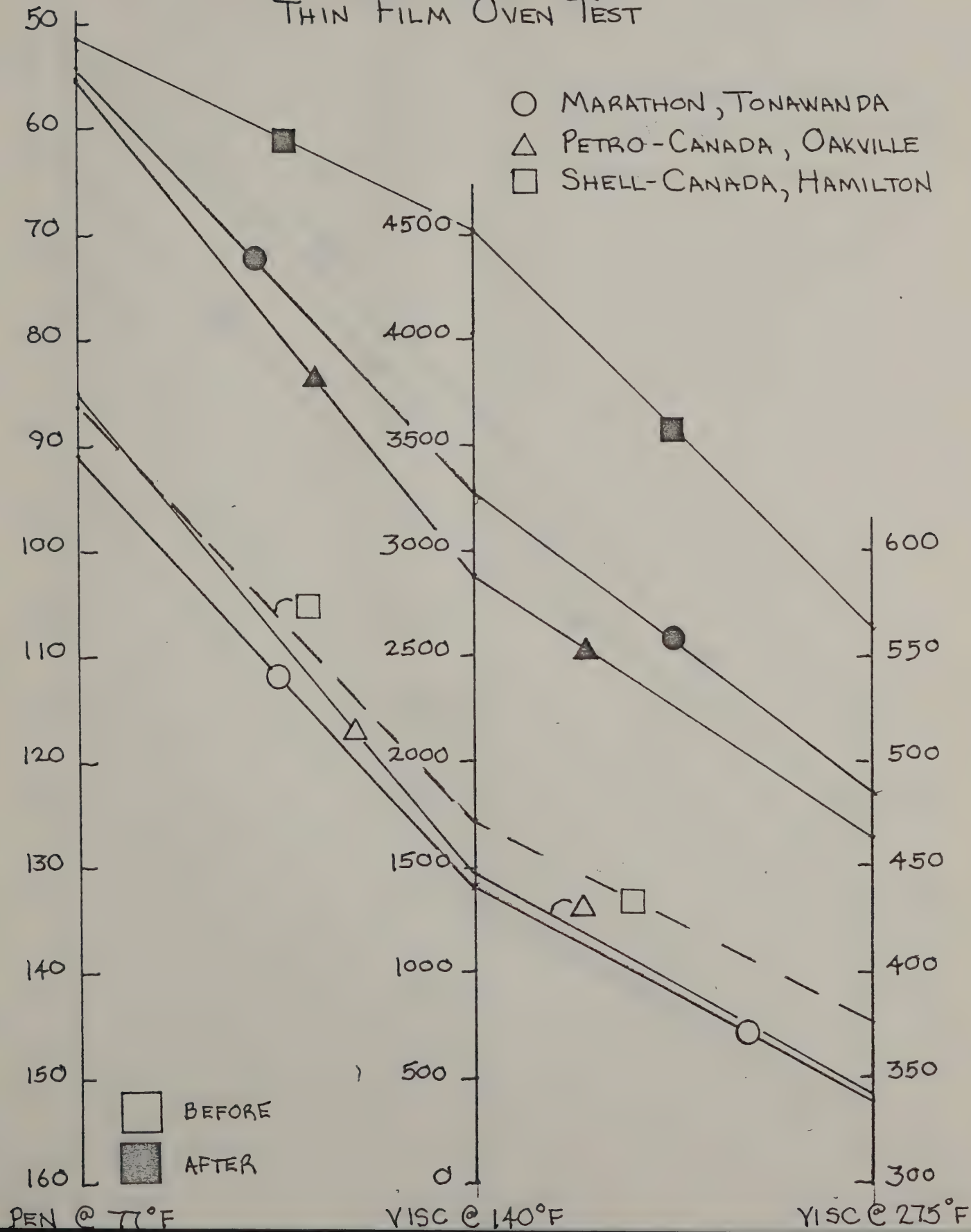


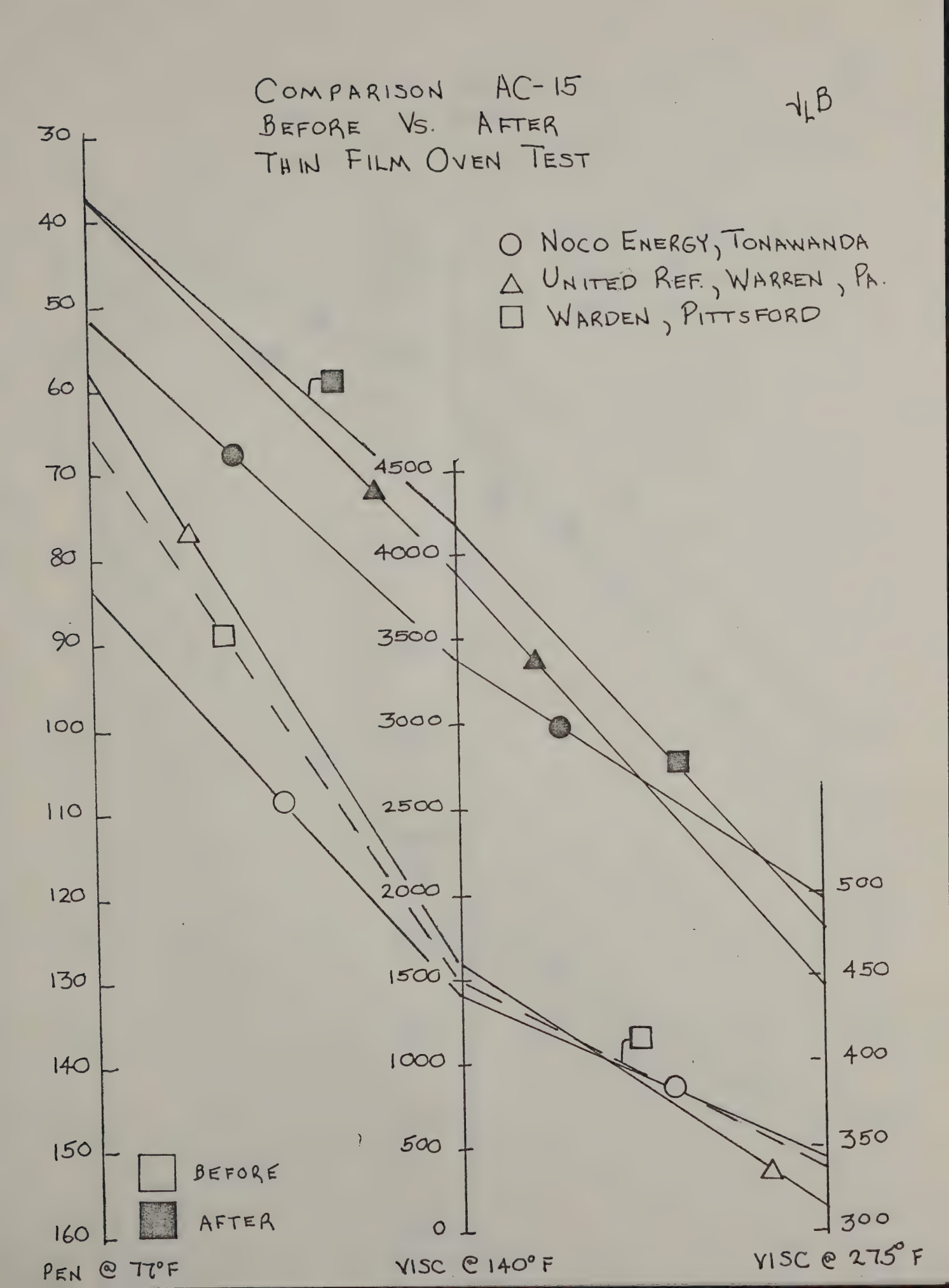


COMPARISON AC-10
BEFORE VS. AFTER
THIN FILM OVEN TEST
VLB
○ PARCO, ATHENS
△ PETRO-CANADA, MONTREAL
50
60
70
80
90
100
110
120
130
140
150
160
4000
3500
3000
2500
2000
1500
1000
500
0
550
500
450
400
350
300
BEFORE
AFTER
PEN @ 77°F
VISC @ 140°F
VISC @ 275°F

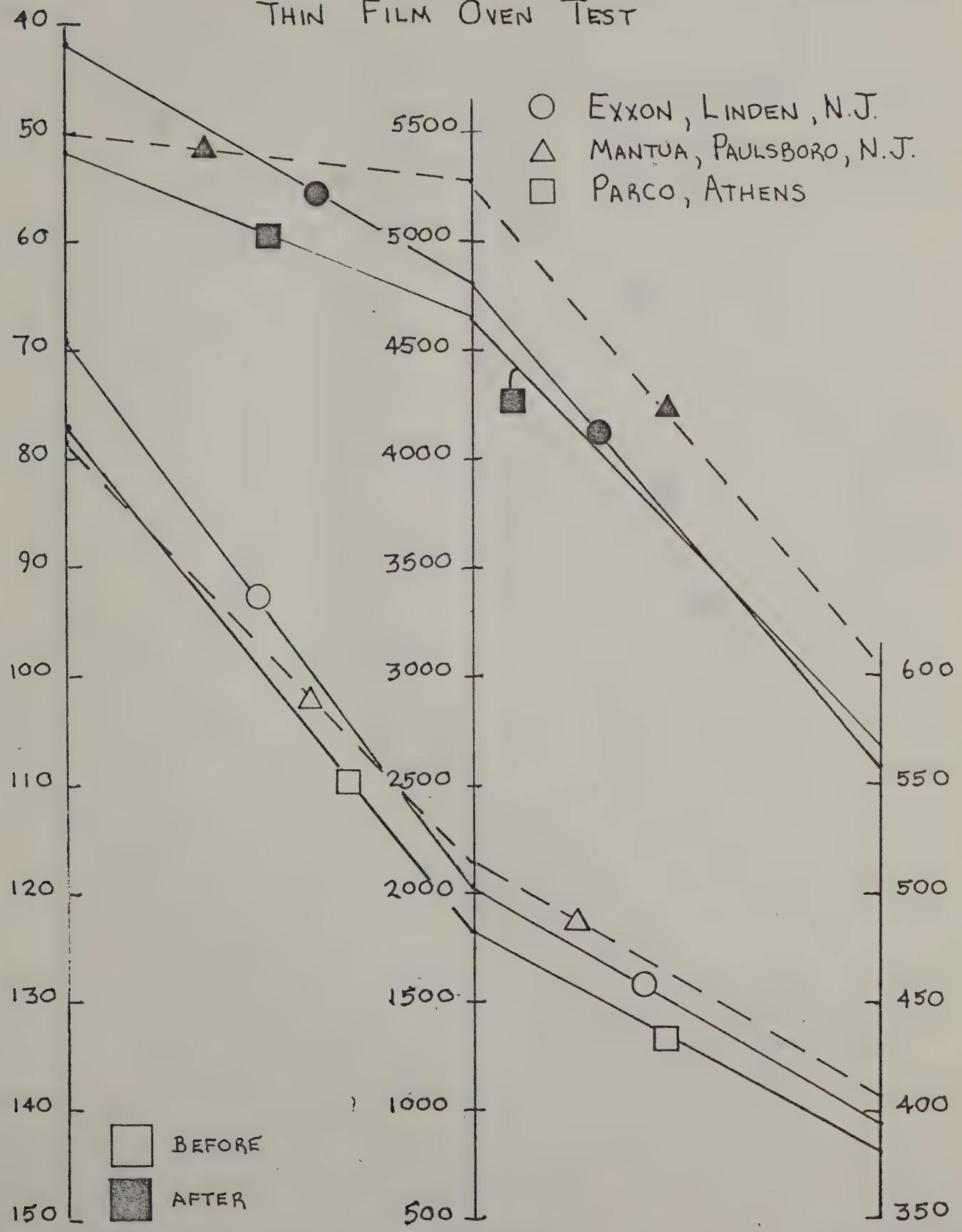
# Comparison AC-15
# Before Vs. After
# Thin Film Oven Test

L.H.B.

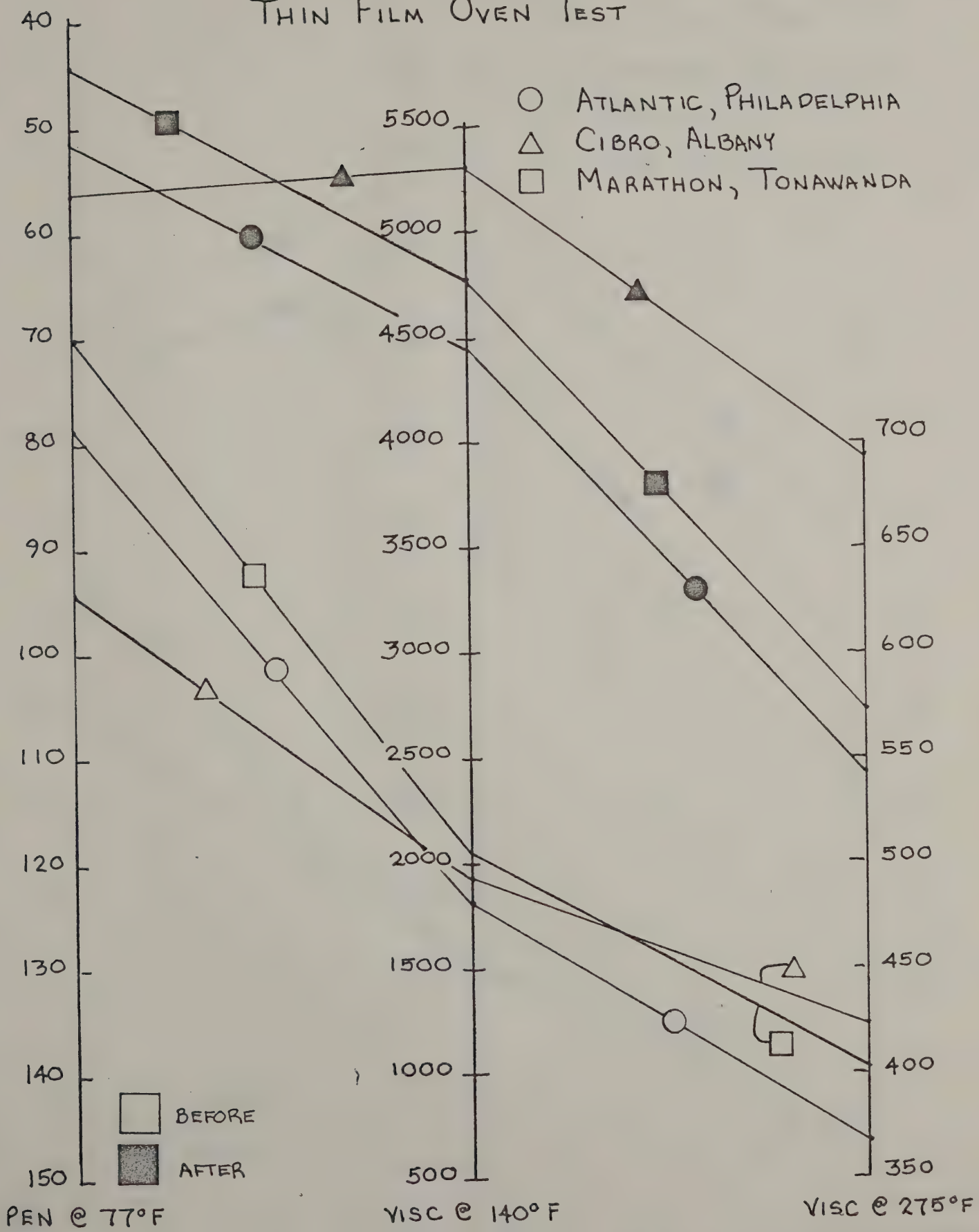


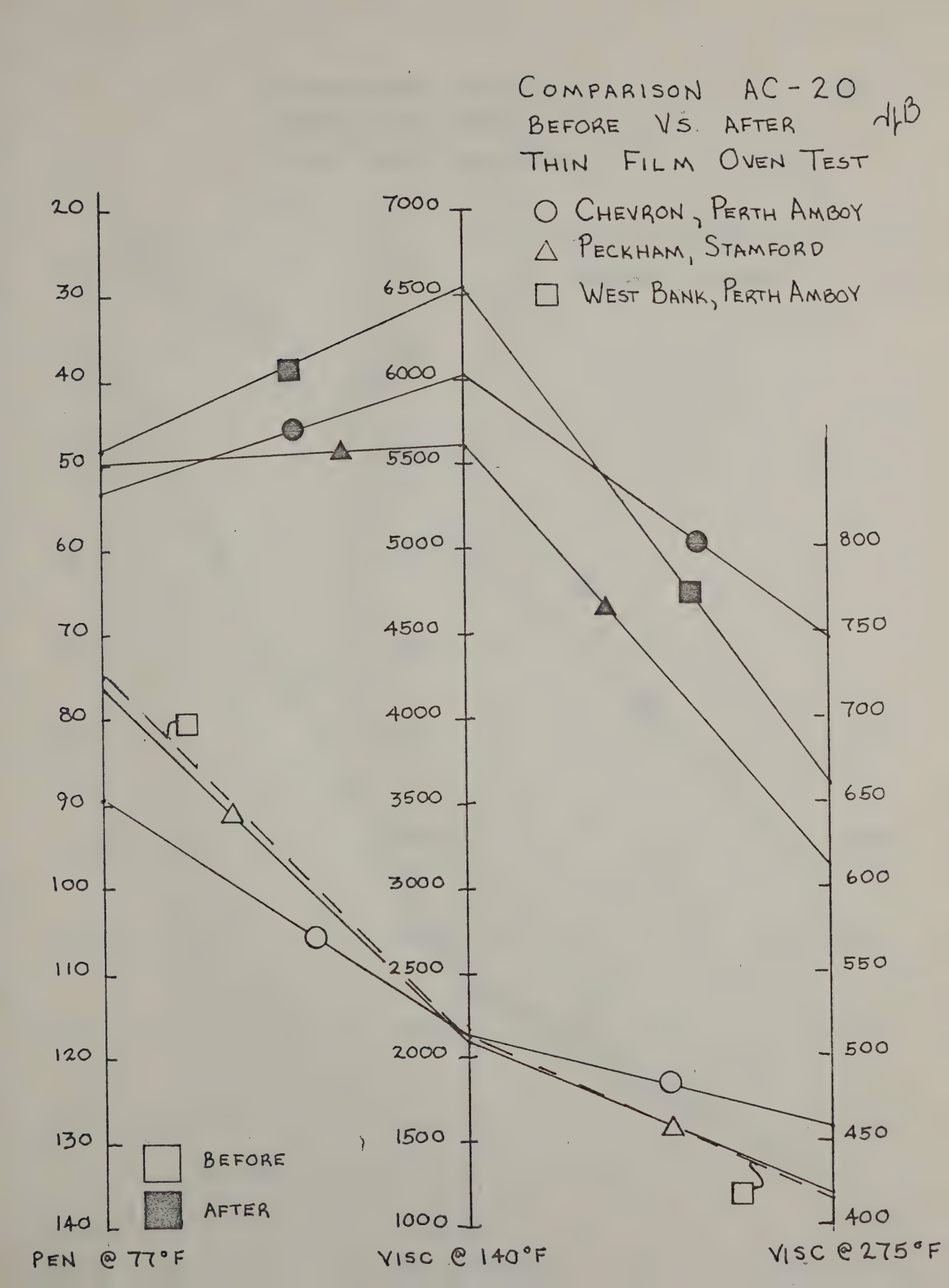

COMPARISON AC-15
BEFORE VS. AFTER
THIN FILM OVEN TEST
VLB
O NOCO ENERGY, TONAWANDA
△ UNITED REF., WARREN, PA.
□ WARDEN, PITTSFORD
30
40
50
60
70
80
90
100
110
120
130
140
150
160
PEN @ 77°F
4500
4000
3500
3000
2500
2000
1500
1000
500
0
VISC @ 140° F
500
450
400
350
300
VISC @ 275° F
BEFORE
AFTER

# Comparison AC-20
## Before Vs. After
## Thin Film Oven Test

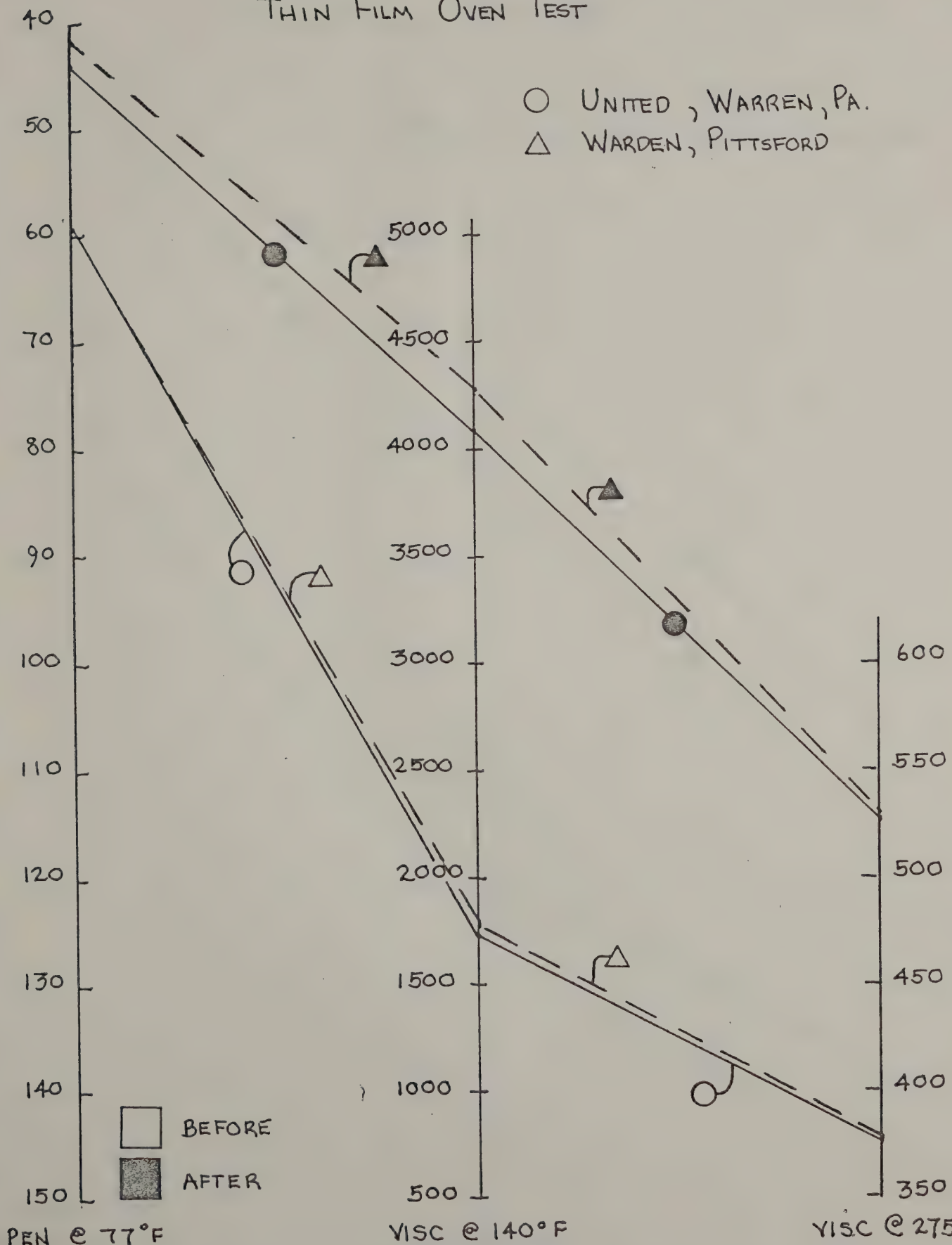


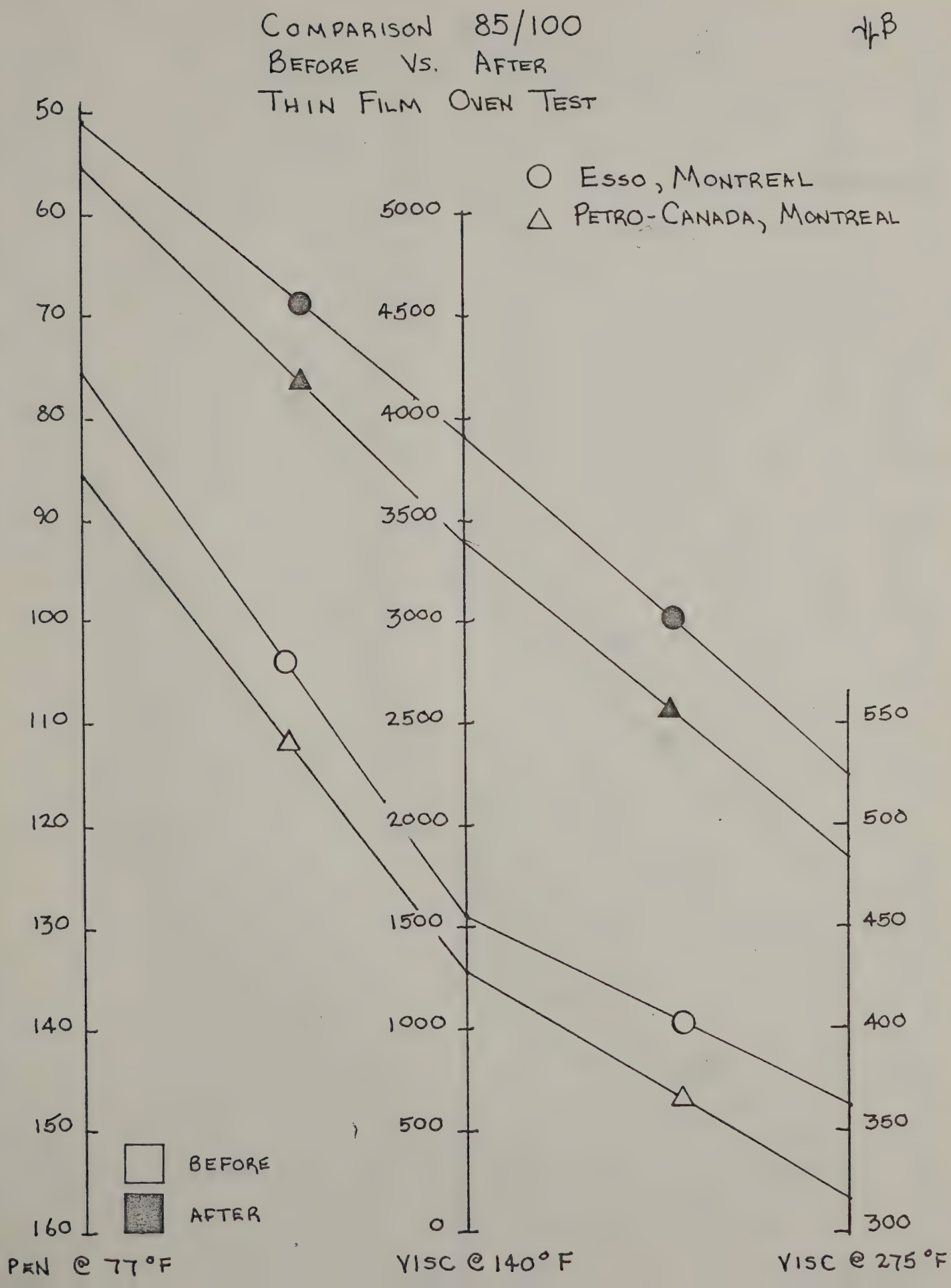
# Comparison AC-20, Before Vs. After Thin Film Oven Test




COMPARISON AC-20
BEFORE VS. AFTER
THIN FILM OVEN TEST
4B
CHEVRON, PERTH AMBOY
PECKHAM, STAMFORD
WEST BANK, PERTH AMBOY
BEFORE
AFTER
PEN @ 77°F
VISC @ 140°F
VISC @ 275°F
20
30
40
50
60
70
80
90
100
110
120
130
140
7000
6500
6000
5500
5000
4500
4000
3500
3000
2500
2000
1500
1000
800
750
700
650
600
550
500
450
400

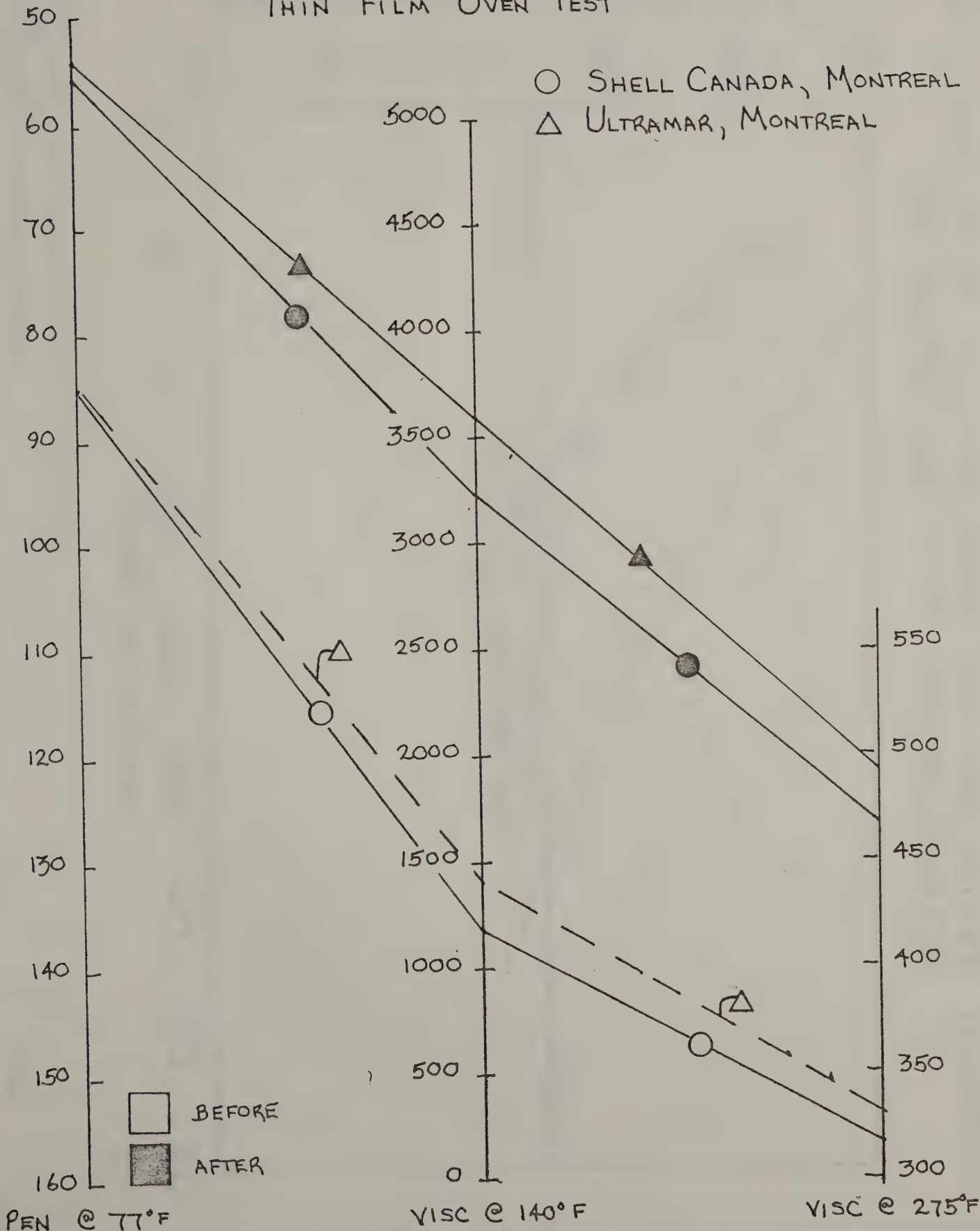
# Comparison AC-20
## Before Vs. After
## Thin Film Oven Test



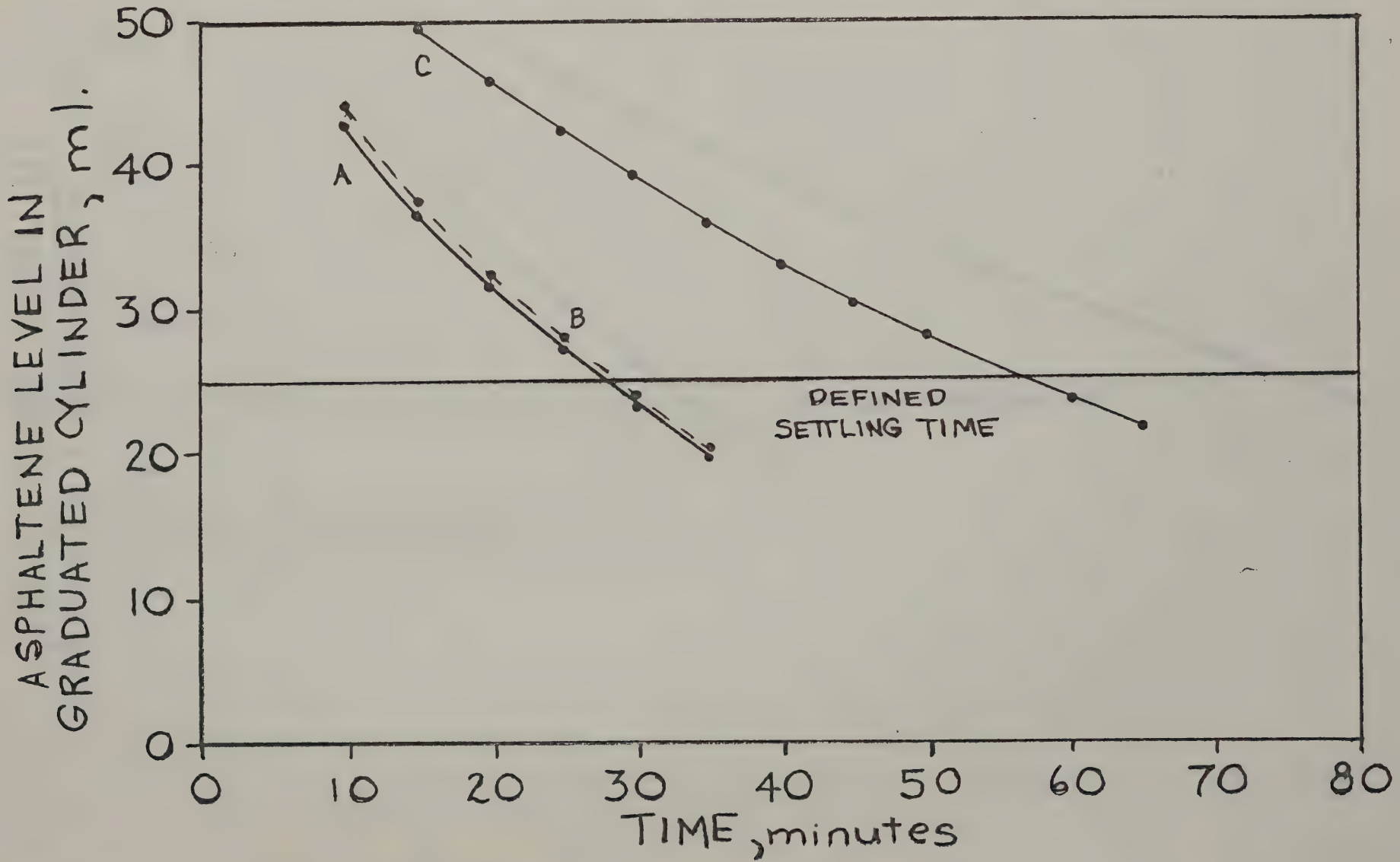


COMPARISON 85/100
BEFORE VS. AFTER
THIN FILM OVEN TEST
ESSO, MONTREAL
PETRO-CANADA, MONTREAL
50
60
70
80
90
100
110
120
130
140
150
160
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
550
500
450
400
350
300
BEFORE
AFTER
PEN @ 77°F
VISC @ 140°F
VISC @ 275°F

# Comparison 85/100 Before Vs. After Thin Film Oven Test



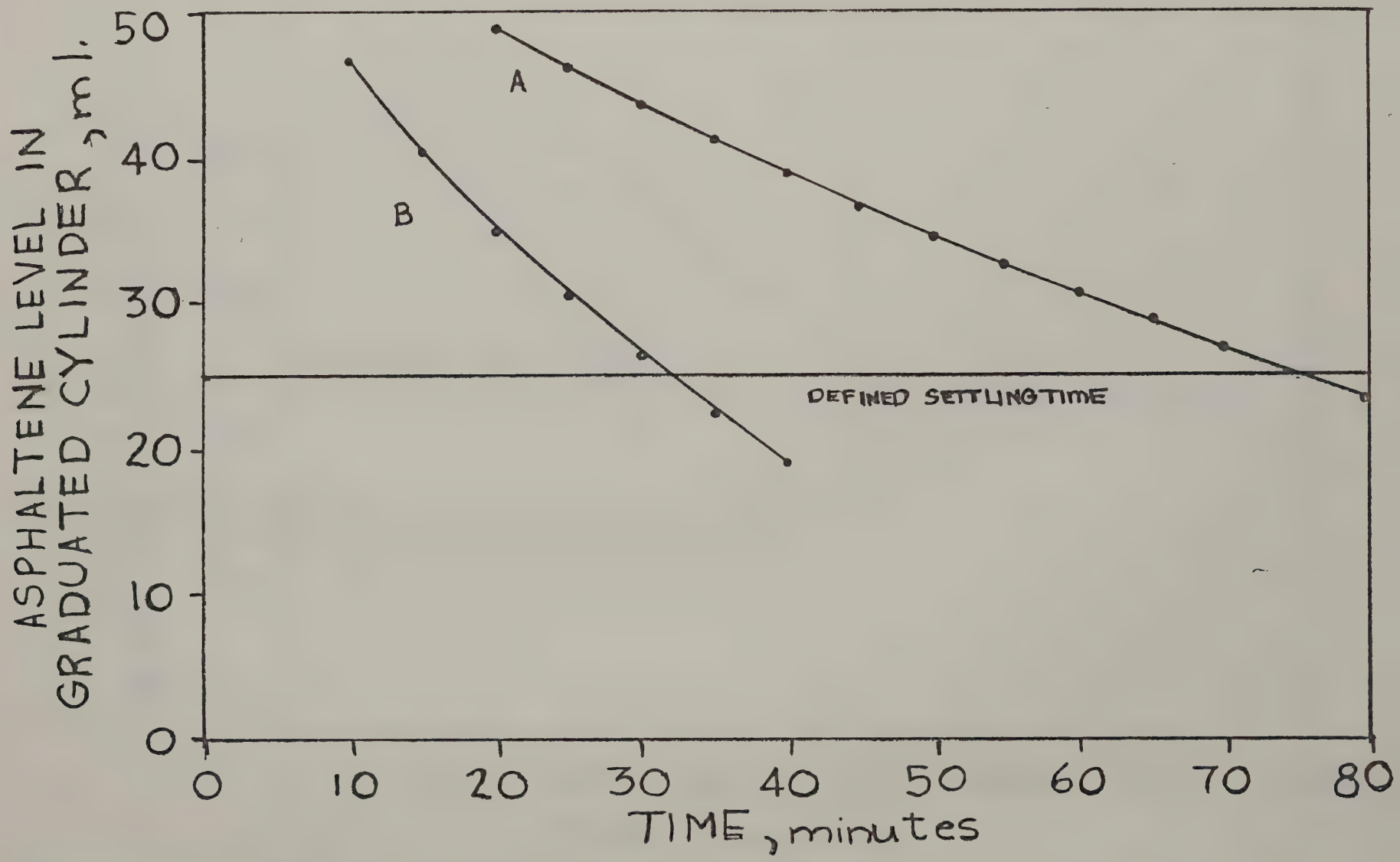
# A SETTLING TEST TO EVALUATE THE RELATIVE DEGREE OF DISPERSION OF ASPHALTENES




A = FLUX, CHEVRON, PERTH AMBOY
B = FLUX, CIBRO, ALBANY
C = FLUX, MARATHON, TONAWANDA

II-B

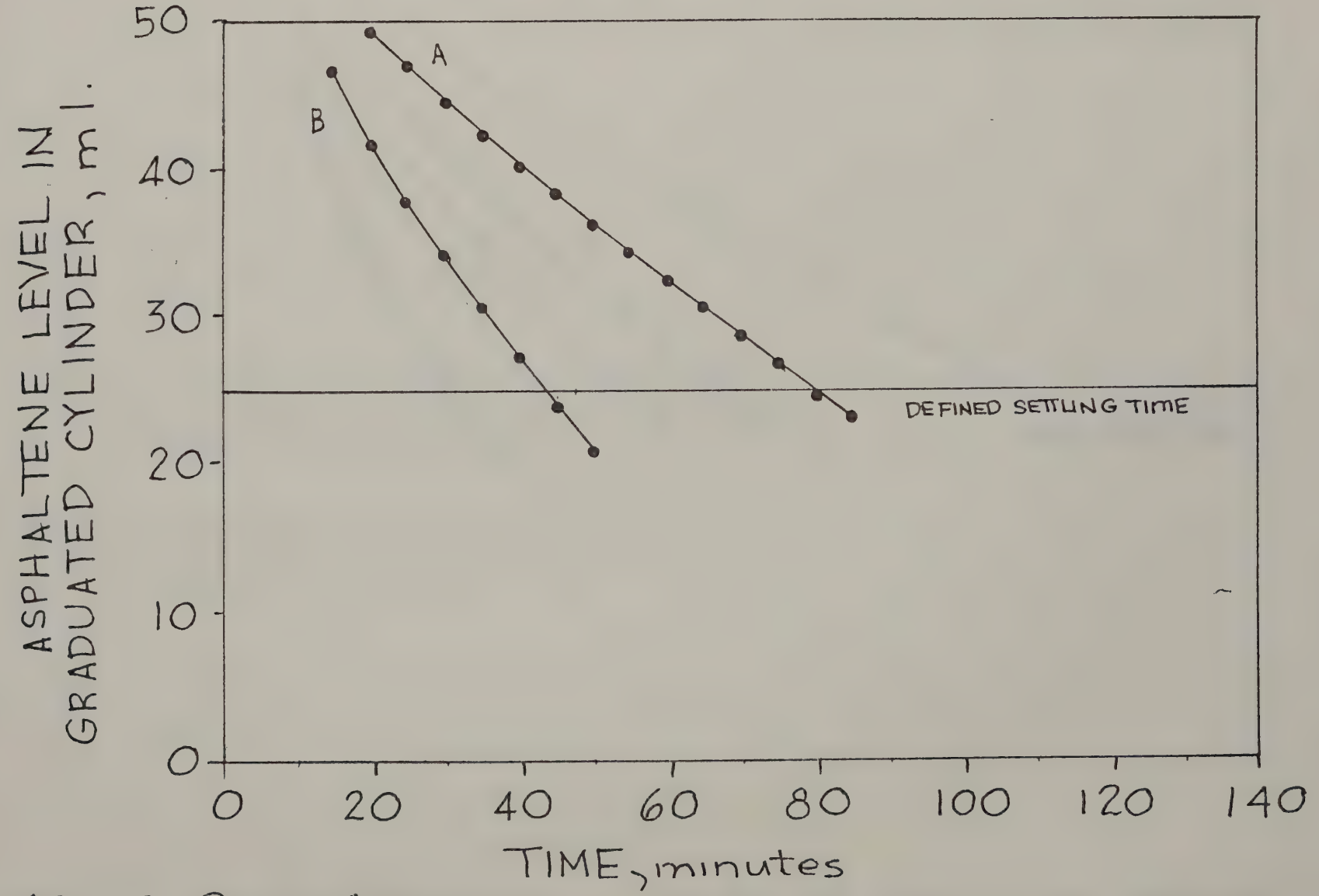
# A SETTLING TEST TO EVALUATE THE RELATIVE DEGREE OF DISPERSION OF ASPHALTENES




A = PARCO - ATHENS, AC-5
B = PETRO-CANADA, OAKVILLE, AC-5

LB

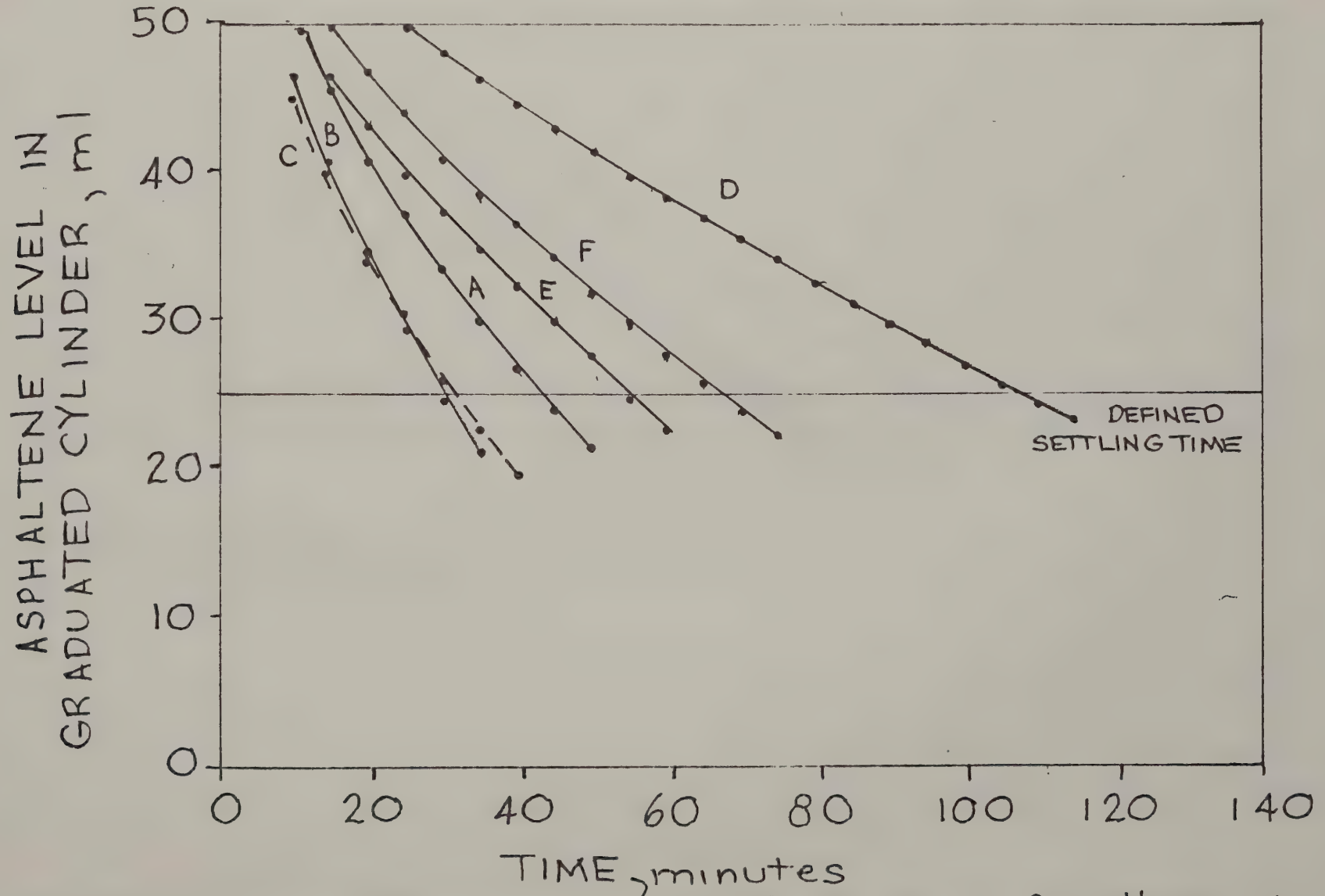
# A SETTLING TEST TO EVALUATE THE RELATIVE DEGREE OF DISPERSION OF ASPHALTENES




A = AC-10, PARCO, ATHENS
B = AC-10, PETRO-CAN., MONTREAL

JLB

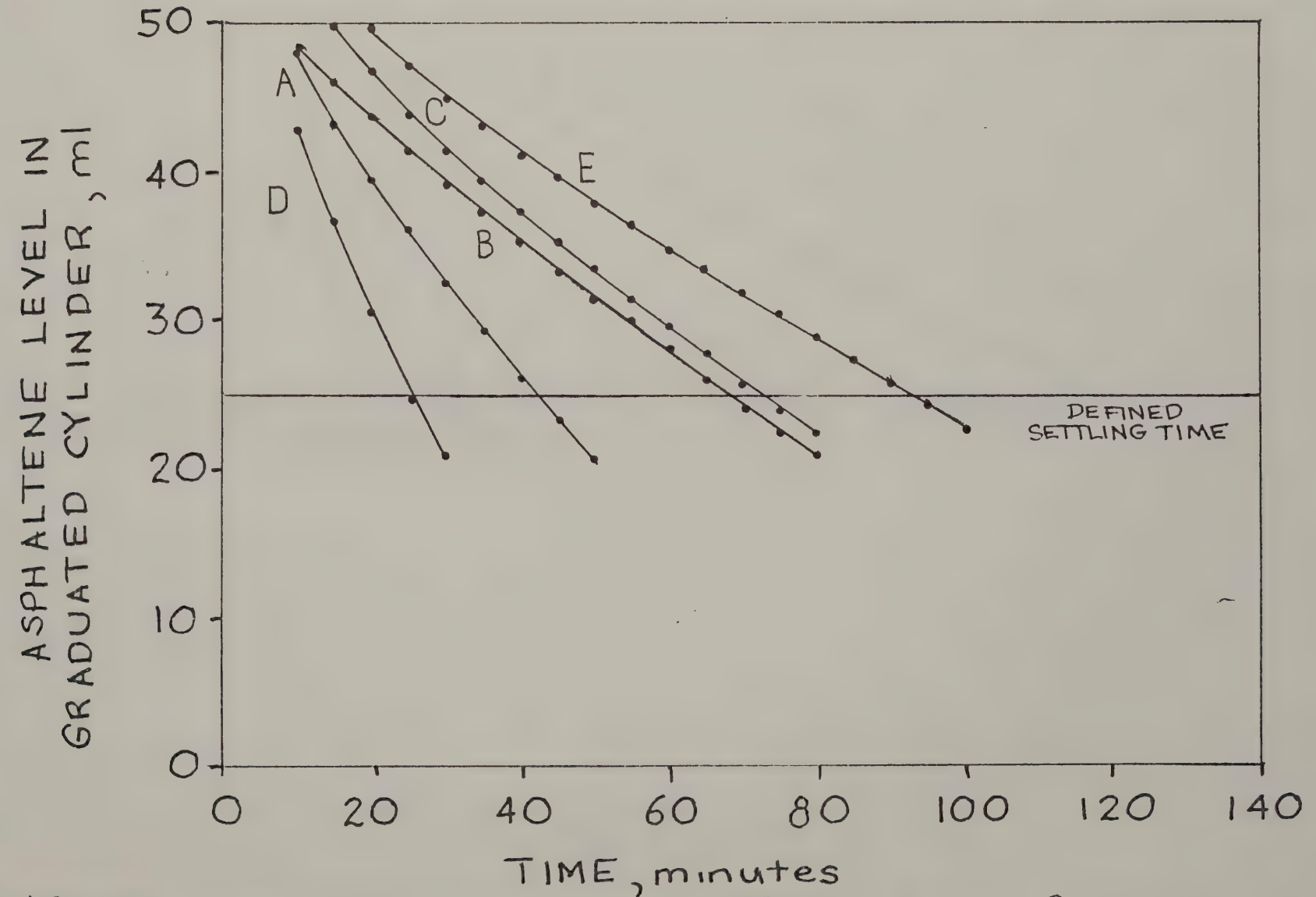
# A SETTLING TEST TO EVALUATE THE RELATIVE DEGREE OF DISPERSION OF ASPHALTENES




A = AC-15, MARATHON, TONAWANDA
B = AC-15, NOCO, TONAWANDA
C = AC-15, PETRO-CAN., OAKVILLE
D = AC-15, SHELL-CAN., HAMILTON
E = AC-15, UNITED REF., WARREN
F = AC-15, WARDEN, PITTSFORD

JLB

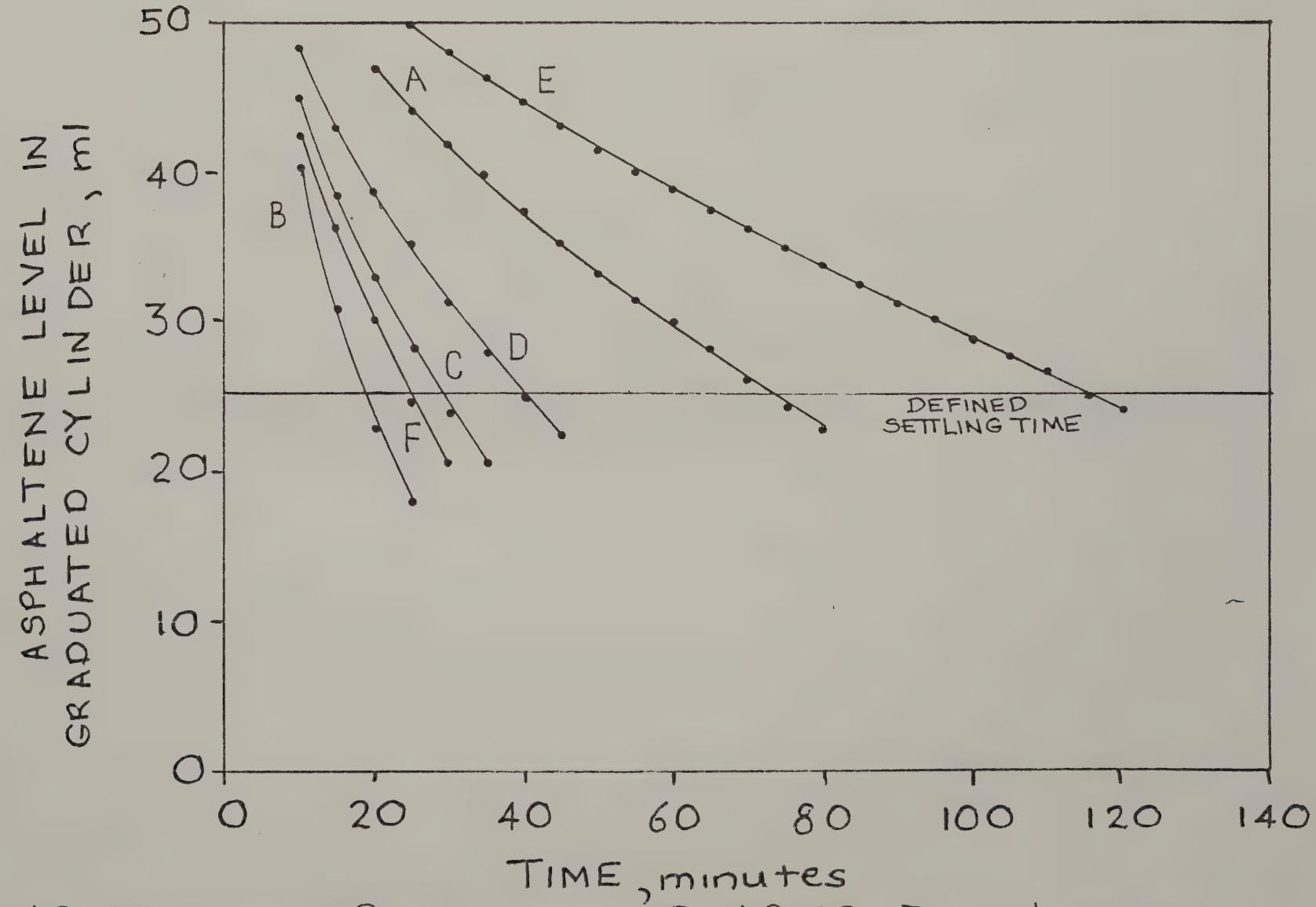
# A SETTLING TEST TO EVALUATE THE RELATIVE DEGREE OF DISPERSION OF ASPHALTENES




A = AC-20, MARATHON, TONAWANDA
B = AC-20, PARCO, ATHENS
C = AC-20, PECKHAM, STAMFORD
D = AC-20, WARDEN, PITTSFORD
E = AC-20, WEST BANK, PERTH AMBOY

NLB

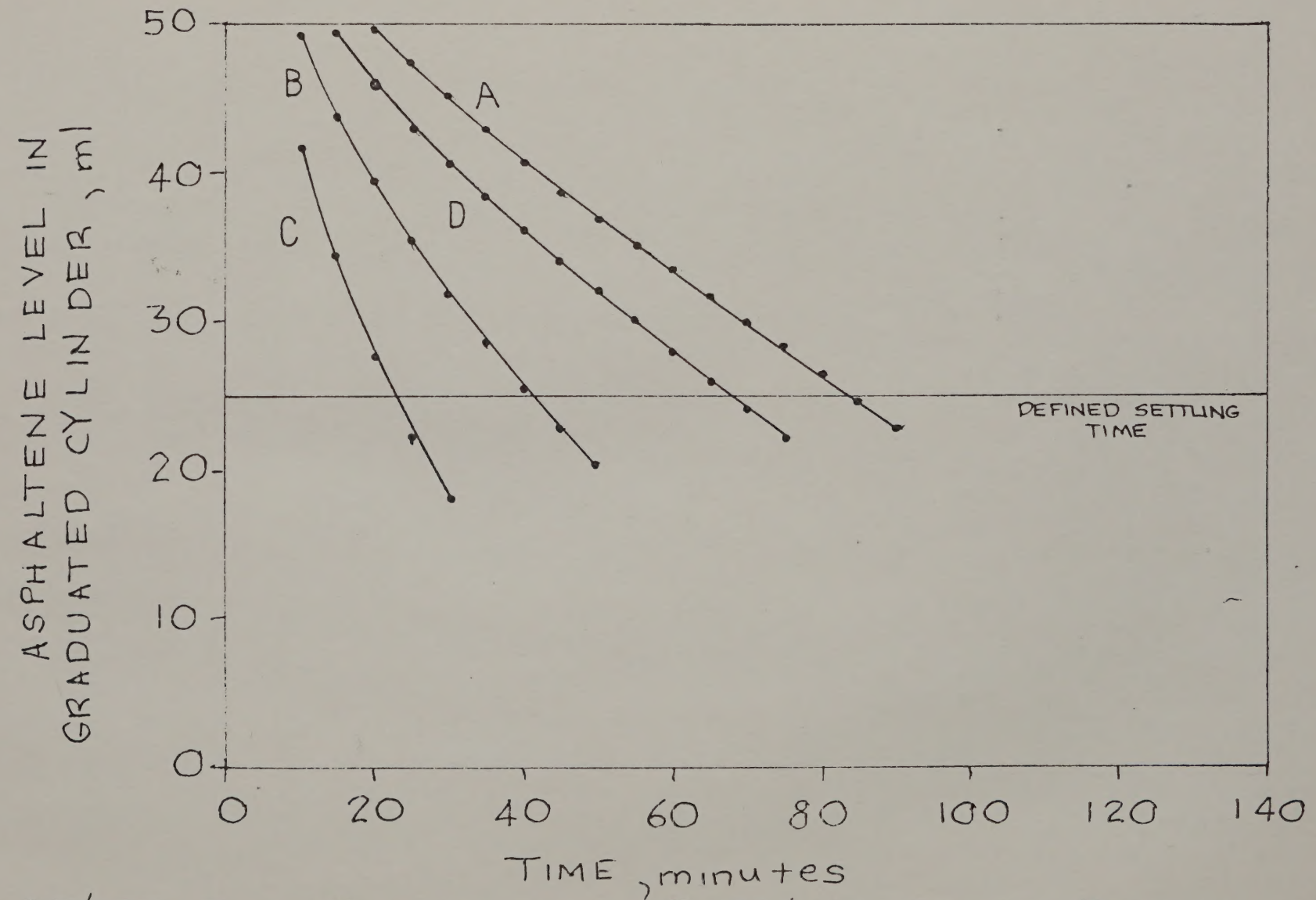
# A SETTLING TEST TO EVALUATE THE RELATIVE DEGREE OF DISPERSION OF ASPHALTENES




A = AC-20, ATLANTIC, PHILADELPHIA
B = AC-20, CHEVRON, PERTH AMBOY
C = AC-20, CIBRO, ALBANY
D = AC-20, EXXON, LINDEN
E = AC-20, MANTUA, PAULSBORO
F = AC-20, UNITED, WARREN

HB

# A SETTLING TEST TO EVALUATE THE RELATIVE DEGREE OF DISPERSION OF ASPHALTENES




A = 85/100, Esso, Montreal
B = 85/100, Petro-Can., Montreal
C = 85/100, Shell-Can., Montreal
D = 85/100, Ultramar, Montreal

HB

01549
LRI